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ERRATA

Page 101, line 9 from bottom, *read* acervuli *for* acereuli; last line, *read* ovoid *for* ovid.

Page 196, line 4, *read* have been the first to find *for* have found the first.

Page 198, line 10 from bottom, *read* animal-cell *for* animal.

Page 201, interchange line 12 and line 13.

Cover of May number, *read* Reiner Bonde *for* Reaner Bonde; *read* Holmes *for* Holme.

Page 261, last line of third paragraph, *read* (Stoneman) *for* (Atk.).

Page 330, last line of table 3, *read* Cankered to same extent as No. 13 *for* Cankered to same extent as No. 12.

Page 375, line 2, *read* N. S. N. II–15–44 *for* N. S. N. II–15–114.

Page 483, line 11, *change* stalked *to* stalk.

Page 565, table 1, interchange headings of last two columns.

Page 675, reference 7, *read* 364 *for* 384, and 1923 *for* 1925.

Page 712, line 23, *read* Sclerotia rare or absent *for* Sclerotia absent.

Page 713, reference 3, *read* C. C. Lindegren *for* C. C. Lindgren; reference 4, *read* Further studies on the toxicity of juice *for* Further studies on the juice.

Page 723, line 25 and line 31, *read* Leaf blight *for* Late blight.

Page 791, line 8, parentheses should be omitted.

Page 795, reference 1, *read* Jour. Hered. 11 *for* Jour. Hered. 2; reference 2, *read* Amer. Jour. Bot. 11: 123–158 *for* Amer. Jour. Bot. 9: 123–159.

Page 804, line 1, *read* infection by *H. gramineum*, through artificial inoculations *for* artificial infection by *H. gramineum*, through inoculations.

Page 807, line 22, *read* Anna E. *for* Anna A.

Page 808, line 12, *read* They *for* He.

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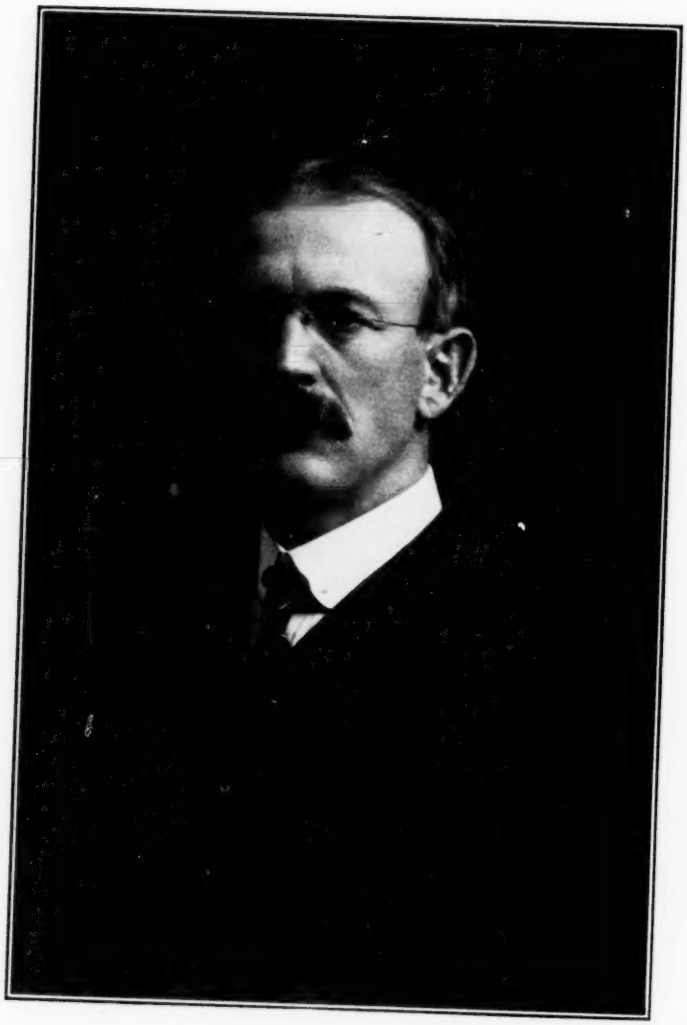

AUGUSTINE DAWSON SELBY

PHYTOPATHOLOGY

VOLUME XV NUMBER 1

JANUARY, 1925

AUGUSTINE DAWSON SELBY
1859–1924

W. G. STOVER

WITH PORTRAIT, PLATE I

Augustine Dawson Selby, sometime President of the American Phytopathological Society, and for nearly thirty years Botanist of the Ohio Agricultural Experiment Station, died at Wooster, Ohio, May 7, 1924.

He was born near Sharpsburg, Athens County, Ohio, September 2, 1859. He grew up on the farm and retained throughout his life a practical interest in the difficulties and problems confronting the grower of plants, whether on the farm, in the orchard or in the greenhouse. He was married December 15, 1883, to Miss Libbie Glover, of Hilliards, Ohio. She and an only son, Warren F. Selby, an attorney at Akron, Ohio, survive.

In his younger manhood he taught in the public schools for several years. He was superintendent of schools at Huntington, W. Va., and principal of schools at Ironton and Columbus, Ohio. He began his life's work in botany as a teacher of that subject in the Columbus High School from 1889 to 1894. During this period he also carried on collegiate studies at Rutgers College and at Ohio State University, receiving from the latter the degree of Bachelor of Science in 1893.

At these schools he came in contact with two men who greatly influenced his further scientific work. Dr. B. D. Halsted had, in 1889, entered upon his long career at the New Jersey institution, and had published several of the papers on plant diseases for which he became noted among the botanists of America. Dr. W. A. Kellerman, who had begun at the Kansas Agricultural College his important work on cereal diseases, especially the smuts and their control, was continuing these and other mycological and pathological studies in Ohio. Professor Selby also studied at Washington University and the Shaw School of Botany in 1899, and at Columbia University in 1902–3.

In September, 1894, he assumed his duties at the Ohio Agricultural Experiment Station which had been moved from the campus of Ohio State University to Wooster in 1892. Although the station had been established twelve years earlier, its resources were meager and its staff was small. Professor Selby, as he was familiarly known to his associates and to thousands

of Ohio farmers, undertook and developed the station work in the two important lines of botany and chemistry. In 1902, however, a separate department of chemistry was established, and Professor Selby gave his time during the remainder of his active life to studies in botany, plant pathology and plant breeding.

A study of oats smut and its prevention (1895) was the first of a long series of bulletins and circulars bringing to the attention of Ohio farmers the results not only of his own experiments and observations but also those of scientific workers in other states and in foreign countries. In successive bulletins he summarized in an able manner the scientific knowledge of the day on the diseases of the peach, cucumber, muskmelon, tomato, tobacco, wheat and other crop plants, always including valuable suggestions from his own observations or investigations. When we consider the meager knowledge concerning plant diseases available to the farmer at that time, it appears impossible to overestimate the value of these contributions. Of a similar character, on a larger scale, is "A condensed handbook of the diseases of cultivated plants in Ohio" (1900) which was later revised and extended (1910). This handbook was, at the time of its publication, the only general compilation of the American aspects of phytopathology. In consequence, it was widely used outside of Ohio and was, in fact, for nearly a decade the standard text book on the subject.

His work as Station Botanist was in large part practical in nature. He conducted extensive experiments on spraying the peach, grape, tomato, cucumber, muskmelon and other plants in various parts of the state, and on seed treatment of wheat, oats and potato, continuing the work until definite results were obtained in each case. He was the first to suggest the use of the formaldehyde drip method for the control of onion smut, and was the first to report the occurrence in America of *Thielavia basicola* (B. and Br.) Zopf.

In addition to his work on plant diseases he gave considerable attention to the native plants and the weeds of Ohio. Besides a number of shorter papers he published "A first Ohio weed manual" (1897) and "A second Ohio weed manual" (1906). Several seasons (1897–1900) were occupied in part with sugar-beet investigations, and for a number of years following 1903 he supervised the work on tobacco breeding at the Germantown substation in the heart of the Miami Valley tobacco section.

During his later years, Professor Selby's health was not of the best, and he limited himself more to administrative and office duties, although he continued his visits to growers in various parts of the state as necessary. On several occasions he expressed to the writer his desire to remain "in the harness" as long as possible in order that he might continue to have some mental occupation. He retired July 1, 1923.

Dr. Charles E. Thorne, Director of the Ohio Agricultural Experiment Station for many years, writes of him:

"My first acquaintance with Mr. Selby was when, as a young student at the Ohio State University, he applied for employment on the University farm. I have always carried, in the picture gallery of my memory, a view of his pleasant address when we first met, and when, in 1894, his name was suggested by my coadjutor, W. J. Green, for the position of Botanist and Chemist at the Experiment Station I was glad to invite him to that position.

"At that time the Station had just been relocated in Wayne County, a relocation involving serious differences of opinion and tedious legislation, and its resources were not such as to justify the employment of separate heads for these two important lines of work, but Mr. Selby entered upon the work with enthusiasm and ability, soon calling young assistants to his aid, and thus he carried the work forward until increasing support of the Station's work made it possible to release him from responsibility for the chemical work and concentrate his energies upon his favorite studies in Botany and Vegetable Pathology.

"Born and reared on an Ohio farm, a farm of which he eventually became the owner and possession of which he retained through life, he always maintained a sincerely appreciative interest in the farmers' problems, and his publications on the control of weeds and plant diseases were prepared with the actual conditions of the farm always in view.

"He was constantly on the lookout for new dangers threatening the interests of the farm in his field of work, and was always ready to devote his energies to their control.

"His health was never perfect, and he spent parts of several winters on leaves of absence in southern climates—Italy, Cuba, the Isle of Pines, and South America.

"His church affiliations were with the Episcopalians, and he belonged to the Masonic order."

Professor Selby began his work on plant diseases during the pioneer epoch of American phytopathology, before the organization of the large graduate departments of plant pathology in our universities and before the development of much of the technique of the present-day plant disease laboratory. Much that we now rightly consider elementary information was then unknown. He played no small part in bringing the science to its present development and especially in carrying the results of research and experiment to the farmers of his state, notwithstanding the fact that his work was often limited by lack of funds.

Professor Selby was one of the earliest and most persistent advocates of the organization of the American Phytopathological Society, and took a very active part in the stormy discussions that attended its birth. To its

organization he contributed freely of both time and money, and no one was more gratified than he at the rapid growth of the Society and particularly at the success of its journal. He had infinite faith in the future of plant pathology, and confidently looked forward to the day when there would be "a plant pathologist in every county."

Professor Selby was a Fellow of the American Association for the Advancement of Science and member of the Council in 1911; a member of the Botanical Society of America; a member of the American Phytopathological Society (one of the charter members) and its President in 1911; a member of the Torrey Botanical Club; a charter member of the Ohio State Academy of Science and its President in 1901; a member of the St. Louis Academy of Sciences; a member of the American Genetic Association, and a member of the Ohio State Horticultural Society.

PUBLICATIONS OF PROFESSOR A. D. SELBY

1888

Notes on the chemical composition of some small fruits. Jour. Columbus Hort. Soc. **3**: 99–103.

1889

Some economic products of Rosaceae. Jour. Columbus Hort. Soc. **4**: 18–20.

Report of the committee on botany. Do. **4**: 34, 107–108, 1889; **5**: 23, 85–86, 1890; **6**: 63, 111, 1891; **7**: 67–68, 109–111, 1892.

1890

The uses of a knowledge of botany. Jour. Columbus Hort. Soc. **5**: 33–36.

The snowy trillium. Do. **5**: 36, pl. 3.

Wild carrot. Do. **5**: 70–72.

History of the culture of celery. Do. **5**: 105–106.

A preliminary list of the plants of Franklin County, Ohio. Do. **5**: 1–19. Joint author with Moses Craig.

1891

Our native oaks. Jour. Columbus Hort. Soc. **6**: 41–45, 3 pls.

The geographical distribution of ferns. Do. **6**: 82–84.

Some troublesome weeds and the Ohio statutes relating to weedy plants. Do. **6**: 96–99.

Notes from Columbus, Ohio. Bot. Gaz. **16**: 148–149.

1892

Commercial floriculture in the United States. Jour. Columbus Hort. Soc. **7**: 16–18.

New Jersey notes. Do. **7**: 83–85.

1893

Analytical synopsis of the groups of fungi. Ohio Agric. Exp. Sta. Tech. Bull. **1**: 206–213. Joint author with W. A. Kellerman.

The Ohio Erysipheae. Do. **1**: 213–224.

Notes on rare Ohio plants. Do. **1**: 241.

A peculiar Hydrophyllum. Jour. Columbus Hort. Soc. **8**: 128–130.

Report for committee on vegetable pathology. (With varying title.) Do. **8**: 56–57. 1893; **10**: 138–143. 1895; **24**: 16–23. 1910; **25**: 13–19. 1911; **26**: 13–24. 1912.

Poisonous plants. Do. **8**: 119–128.

The leaf mildews. Do. **8**: 23–25.

1894

Progress in the study of the fungus of wheat scab. Ann. Rep. Ohio St. Acad. Sci. **2**: 33–34.

Notes on Erysipheae. Do. **2**: 36–37.

The Russian thistle in Ohio. Jour. Columbus Hort. Soc. **9**: 127–132, pl. 6, 7.

The Russian thistle in Ohio and weeds in general. Ohio laws relative to weeds, black-knot and yellows. Ohio Agric. Exp. Sta. Bull. 55: 53–69, pl. 1–3.

1895

Preliminary notes on the diseases of the peach. Ann. Rept. Ohio St. Hort. Soc. **28**: 95–103.

Report of the Botanist. Thirteenth Annual Report Ohio Agricultural Experiment Station. Ohio Agric. Exp. Sta. Bull. 58: xl–xlii.

Noxious weeds along thoroughfares and their destruction. Do. 59: 1–5. 1895.

The smut of oats and its prevention. Ohio Agric. Exp. Sta. Bull. 64: 115–139.

Report of the Botanist. Fourteenth Annual Report Ohio Agricultural Experiment Station. Ohio. Agric. Exp. Sta. Bull. 66; xxxiv–xlii.

Notes on some newly introduced plants. Ann. Rep. Ohio St. Acad. Sci. **3**: 18–19.

The treatment of greenhouse plants with bisulphide of carbon for the destruction of red spider and aphides. Amer. Florist. **10**: 783–784. *1 fig.* 1895. Joint author with F. M. Webster.

1896

The brown pustular spot of the peach—first results in its prevention. Ann. Rep. Ohio St. Hort. Soc. **29**: 80–84, fig. 1.

Peach yellows in Ohio orchards. Do. **29**: 60–64.

Galls of raspberry, peach and pear. Do. **29**: 74–76, pl. 1.

Certain troublesome diseases of tomatoes and cucurbits. Jour. Columbus Hort. Soc. **11**: 113–116.

Peach yellows, black knot and San José scale. Ohio Agric. Exp. Sta. Bull. 72: 193–210. Joint author with F. M. Webster.

Ohio black knot, yellows and San José scale law. Do. 72: 218–220.

Investigations of plant diseases in forcing-house and garden. Do. 73: 221–246, pl. 1–4.

Report of the Botanist. Fifteenth Annual Report Ohio Agricultural Experiment Station. Do. 74: xxxvii–xl.

1897

Report of the committee on vegetable pathology (with slightly varying titles.) Ann. Rep. Ohio St. Hort. Soc. **30**: 40–44, 1897; **31**: 82–86, 1898; **32**: 110–117, 1899; **33**: 44–52, 1900; **34**: 72–93, 1901; **35**: 82–87, 1902; **36**: 105–110, 1903; **37**: 127–132, 1904; **38**: 137–141, 1905; **39**: 65–69, 1906; **42**: 68–74, 1909; **43**: 77–84, 1910; **44**: 38–48, 1911; **45**: 33–42, 1912; **46**: 100–110, 1913; **47**: 98–103, 1914; **48**: 83–87, 1915; **49**: 16–21, 1916; **50**: 21–25, 1917; **51**: 52–61, 1918; **52**: 28–31, 1919; **53**: 58–60, 1920; **54**: 28–31, 1921; **56**: 142–146, 1923.

Some diseases of orchard and garden fruits with spray calendar supplement. Ohio Agric. Exp. Sta. Bull. 79: 97–141, pl. 1–9, figs. 1–10.

Corn smut. Do. 78: 92–96. Joint author with J. F. Hickman.

A first Ohio weed manual. Do. 83: 249–400, fig. 1–70.

Prevalent diseases of cucumbers, melons and tomatoes. Do. 89: 99–122, pl. 1–3.

Spraying of peaches. Ann. Rep. Ohio St. Hort. Soc. 30: 87–91.

Unlisted Ohio fungi. Ann. Rep. Ohio St. Acad. Sci. 5: 70.

Some Ohio Metaspermae. Do. 5: 70–73.

1898

Diseases of cucumbers, melons and tomatoes and their prevention. Ann. Rep. Ohio St. Hort. Soc. 31: 94–99, pls. 2.

Preliminary report upon diseases of the peach; experiments in spraying peach trees. Ohio Agric. Exp. Sta. Bull. 92: 176–268, pl. 1–12, fig. 1–12.

Some diseases of wheat and oats. Do. 97: 31–43, fig. 1–4.

Experiments in the prevention of grain smuts. Do. 97: 43–61. Joint author with J. F. Hickman.

Sugar beet investigations in 1897. Do. 90: 123–162. 1898. Joint author with L. M. Bloomfield.

Can leaf curl of the peach be controlled? Jour. Columbus Hort. Soc. 13: 84–88, pl. 1–2.

1899

Seed and soil treatment and spray calendar for insect pests and plant diseases. Ohio Agric. Exp. Sta. Bull. 102: [broadside]. Joint author with W. J. Green and F. M. Webster.

Further studies upon spraying peach trees and upon diseases of the peach. Do. 104: 201–216, pl. 1–3.

Further studies of cucumber, melon and tomato diseases. Do. 105: 217–235, fig. 1–2.

Investigations of plant diseases. A summary of the work of the . . . station from 1891 to 1899. . . . Do. 111: 98–142, fig. 1–12.

Sugar beet investigations in 1898. Do. 99: 77–122, f. 1.

Variations in the amount of leaf curl of the peach (Exoascus deformans) in the light of weather conditions. Proc. Soc. Prom. Agric. Sci. 20: 98–104.

Additional host plants of Plasmopara cubensis. Bot. Gaz. 27: 67–68.

Sources of the Ohio flora. Jour. Columbus Hort. Soc. 14: 35–59. Joint author with J. W. T. Duvel.

Science training for farm life. Farmer's Institute. Report, 1898–99; 1–6; also Ann. Rept. Ohio State Bd. Agric. 53: 450–455.

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1900

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THE DILOPHOSPORA DISEASE OF CEREALS

D. ATANASOFF

WITH NINE FIGURES IN THE TEXT

INTRODUCTION

The disease here under consideration was seen for the first time about a century ago (9). Since then it has been repeatedly observed on various cereals and grasses and has often caused alarm among agriculturists. Most of the numerous short notes and papers on this subject describe briefly the fungus associated with the disease under the incorrect names of *Dilophospora graminis* Desm. and *Dilophia graminis* Fuckel, while some of them contain also short and incomplete descriptions of the malady itself. No study of the organism, its physiology and pathogenicity has ever been made. The disease, the way in which it develops and the conditions under which it occurs have also never been investigated.

The writer observed this disease for the first time during the summer of 1923 in a field sown with a mixture of wheat, spelt and rye. The symptoms and effects of the disease were so striking that the diseased plants attracted attention from a distance. A large number of plants were already dead. Others were very much deformed, while some of the apparently normal plants had partially or wholly deformed and charred heads.

The presence of numerous pycnidia over all infected areas indicated the fungous nature of the disease. A careful examination of the deformed heads, however, showed in all cases also the presence of numerous nematode galls which were filled with living larvae of *Tylenchus tritici* (Steinbuch) Bastian, the cause of the nematode disease of cereals. The presence of the nematode galls in all infected heads was so constant that it suggested at once that the occurrence of the two diseases simultaneously on the same plants can not be considered a mere coincidence. From the literature on this disease it became evident that the same condition has been observed also by other workers. In view of this it seemed desirable to plan and carry out the experimental work on this problem from the very beginning in connection with the nematode disease.

The two principal questions which had to be answered were: 1. Is *Dilophospora alopecuri* (Fr.) Fr. a pathogene and in position to bring about alone the disease on wheat, spelt, and rye as observed in nature; and 2. Do the nematodes and the disease, which they cause, favor the parasitism of Dilophospora on the same plants.

All of the numerous experiments made in order to answer the first question gave absolutely negative results, in spite of the fact that infection experiments were made with wheat, spelt, and rye of various ages and of the same varieties on which the disease had been observed; soil, seed, and wound infections at various moistures and temperatures of soil and air were also made but the results were in all cases negative.

The answering of the second question was much easier. In numerous infection experiments, made with several thousands of plants, in all cases without exception, typical and abundant symptoms of the Dilophospora disease appeared on all plants simultaneously infected also by the nematode disease. The appearance of the symptoms of the nematode disease preceded in all cases the appearance of the symptoms of the Dilophospora infection, sometimes within a few days, sometimes with longer periods of time.

The experimental results, negative and positive, showed that while *Dilophospora alopecuri* is a good parasite, or at least a very destructive and injurious fungus, it can attack and establish itself successfully only on the plants already suffering from the nematode disease, and only as long as the nematodes are present in the plants. The further spread of the fungus attack stops as soon as the nematodes leave the plants, die, or form galls. What the nematode disease fails to destroy is destroyed by the Dilophospora disease; this it does with remarkable rapidity and thoroughness.

The further investigations showed not only that the pathogenicity of *D. alopecuri* is influenced by the nematode disease, but also that the relation of the two pathogenes is a more complicated one: not only that the nematodes evidently make the plants susceptible to *D. alopecuri* but they are also an important carrier of the spores of this fungus. And what is even more important they, while creeping and crawling between the leaf sheaths on their way to the interior, the growing point, and later to the young head of the plant, take along the spores of the fungus and deposit them on the growing point of the same. Reaching the growing point of the plant by the spores of the fungus, which seems essential for its successful parasitism, can not be accomplished without the nematodes.

For the nematodes this co-parasitism is not only of no advantage but decidedly harmful. Indeed *D. alopecuri* is, as will be shown later, a most important factor in checking the nematode disease in nature.

A co-parasitism of this degree, the absolute dependence of the one parasite upon the second one, and the effective indirect extermination of the second parasite by the first, is for vegetable pathology unique. A further study of this and related cases, however, might show that this phenomenon plays a greater rôle in nature than we now suppose.

The very dependence of the Dilophospora disease on the nematode disease, for which there exist reliable and efficient control measures, makes the

controlling of the first disease an easy matter, since controlling the nematode disease means also controlling the Dilophospora disease.

GEOGRAPHIC DISTRIBUTION OF THE DISEASE

The Dilophospora disease, though not generally known, is quite widely distributed. In Holland the writer so far has observed the disease on several fields near the village of Epen, situated on the Belgian border. Besides Holland (36, p. 28) it has been reported in the course of time on numerous grasses and cereals from various places in France and Germany and occurs occasionally on wild grasses (1) and wheat in England.[1] The disease has been observed also repeatedly in Norway, Denmark, and Switzerland. It has been reported also from Servia (33, p. 398). Bessey (2) observed the disease on *Calamagrostis canadensis* plants gathered in Kenosha County, Wisconsin, U. S. of America.

HOSTS

A large number of plants are attacked by this disease, but all of them belong to the grass family—the Gramineae. Whether the Dilophospora, which has been observed as a parasite on many grasses and cereals, belongs to *D. alopecuri*, the only species described so far, is not at all certain and not very likely. As long as this is not established experimentally the list of host plants given below will be of a provisional character. The plants listed below have been reported as hosts of *D. alopecuri* since the establishment of this genus and species in 1840 (5) and 1828 (9), respectively.

The writer observed the disease only on wheat, rye and spelt in about the same proportions. Infection experiments with these plants gave in all cases 100 per cent of infected plants, while infection experiments with barley and oats so far have given negative results.

In the table below are also given the names of the workers who have observed for the first time the occurrence of Tylenchus galls on the respective host plants. This table shows also very plainly the existence of a certain relation between the Dilophospora and nematode diseases.

ECONOMIC IMPORTANCE

Though there are practically no data regarding the economic importance of this disease its occurrence has often caused great alarm among the agriculturists of various countries. Berkeley (1) writes of this disease that: "In a field of seven acres a fourth of the wheat was diseased to such a degree that many of the ears were altogether abortive, while in the best there were only two or three tolerable grains." Richon (34) writes that in some

[1] According to a letter of Dr. Cotton, Kew, England.

TABLE 1—*First reports of Tylenchus upon the listed host plants. Also the reported occurrence of Dilophospora alopecuri*

Number	Name of host plants	*Dilophospora alopecuri* (Fr.) Fr.		*Tylenchus tritici* (Steinbuch) Bastian or other gall forming nematodes	
		Author	Date	Author	Date
1	*Agrostis sp.*	Desmazières	1840		
2	*Agrostis alba*	Kirchner	1906	Hieronymus	1890
3	*Agrostis vulgaris*	Kirchner	1906	Schlechtendal	1885
4	*Alopecurus agrestis*	Fries	1828		
5	*Alopecurus pratensis*	Sorauer	1874		
6	*Arrhenatherum elatius*	Kirchner	1906		
7	*Calamagrostis canadensis*	Beesey	1906	Bessey	1906
8	*Calamagrostis epigeios*	Diedecke (Jaap)	1907		
9	*Dactylis glomerata*	Kirchner	1890	Jahresber. dän. Samenkontrollstation	?[1]
10	*Festuca ovina*	Karsten	1865	Schlechtendal	1885
11	*Festuca pratensis*	Kirchner	1906		
12	*Festuca rubra*	Kirchner	1906	Jahresber. dän. Samenkontrollstation	?[1]
13	*Phleum pratense*	Rostrup	1905	Hieronymus	1890
14	*Holcus lanatus*	Fuekel	1861	Ritzema Bos	1900
15	*Holcus mollis*	Desmazières	1840		
16	*Secale cereale*	Desmazières	1840	Roffredi	1776
17	*Triticum spelta*	Störmer	1904	Störmer	1904
18	*Triticum vulgare*	Berkeley	1862	Needham	1747

of the fields examined by him the heads and culms infected represented 5 per cent of the yield. Pape (30) states that "this year in Baden one case was observed where part of a field showed 30 per cent infection, so that the occurrence of the disease caused great anxiety in the territories concerned." Kessler (19) on the other hand writing of same cases states that "in judging the injury it should be kept in mind that in general the heads of only 5 per cent of all infected plants come out from the leaf sheath and attain nearly the height of the healthy heads. By far the greatest majority of the infected plants are overlooked by a superficial examination of the fields, so that the estimated loss is usually too low. Only a careful examination discloses the numerous dwarf plants with strongly misformed heads and dead

[1] According to Reh in Sorauer's Handbuch der Pflanzenkrankheiten 3:29. 1913.

culms.'' Schauer (40) writes that during 1921 in Baden, Germany, 30 per cent of the cereals were attacked by Dilophospora.

In the cases observed by the writer there was a decrease in yield in one of the fields of not less than 60 per cent. In full agreement with Kessler the writer observed that while only about 10 per cent of the heads of fully grown plants were infected, there were to be seen, upon closer examination of the fields, a much larger percentage of small and stunted plants, the heads of which were completely destroyed by the fungus. Such plants are usually overlooked by a superficial examination of the fields.

The actual loss due to this disease alone, however, will always be a very difficult matter to estimate, since the disease, as already stated, occurs always together with the nematode disease of the cereal crops. It is certain that this disease is much more injurious than the nematode disease and usually completes the destruction of the plants which are only slightly and partially injured by the nematodes. Losses of as much as 40 to 50 and even more per cent by actual count, have been reported for *Tylenchus tritici* (3, 4). A combination of both diseases under favorable conditions may therefore completely ruin the crop. In some of the writer's experiments the infected plots failed to form any heads whatever, while in others the few heads formed yielded mostly nematode galls.

DESCRIPTION OF THE DISEASE

The symptoms of the disease, as a whole, are so pronounced and singular that it can never be mistaken for other diseases.

Since this disease occurs only on plants attacked by *Tylenchus tritici* knowing the symptoms of the nematode disease in pure form will help us to distinguish the symptoms of the Dilophospora disease and to understand how the symptoms of the two diseases in combination are brought about.

The Nematode Disease

The nematode disease usually becomes apparent by its effect on the heads of the plants, although symptoms of the disease may occur on all parts of the plant above the ground. Under normal conditions the young plants show the first symptoms when in the third or fourth leaf. If the weather is not too cold, symptoms appear sometimes only 15–20 days after sowing. The infected plants can be recognized by the decided wrinkling, rolling and distortion of their upper leaves and the very pronounced swelling of their bases. Such plants do not stand upright; at least at first, they are usually inclined or slightly curved. Their leaves are shorter and wider; the leaf sheaths are also wider, somewhat swollen with strongly hypertrophied mesophyll tissues, they are brittle and stand loose around the inner

FIG. 1. Wheat plant attacked by *Dilophospora alopecuri*. The primary stem in the middle and the lower two leaves of the two tillers are free from the disease. The upper leaves of the tillers show numerous local infections. Base and sheath of the upper leaves are overgrown and glued up by the fungus, which has led to the formation of the knots further below.

leaves or stem of the plant. Some of the effected plants may die shortly after, but usually remain alive, recover from the original effects of the disease, and form dwarfish heads which usually contain only nematode galls. The wheat heads when infected by nematodes usually ripen later than the healthy ones, their chaff is widely open, thus exposing partially the dark brown galls. The chaff of the rye and spelt heads on the contrary remains closely attached to the axis of the heads, so that the gall-free portions of the heads are often two times as thick and wide as the infested ones. In a large number of cases the writer observed that the infected rye and spelt plants had peculiarly curved internodes, forming almost half circles.

The Dilophospora Disease

The first symptoms of the Dilophospora disease on the already typically nematode infested plants, in the writer's experimental work, appeared also when the plants were only 10–15 cm. high and in the third or fourth leaf. These symptoms consist of small, light colored, round or oblong spots on the upper leaf of the plants. These spots are to be seen on the upper leaves immediately after and even before their appearance from the leaf sheaths. The first and second leaves are never attacked by the disease. The spots at first resemble minute insect lesions, but soon attain considerable dimensions. In this stage they resemble superficially powdery mildew lesions. The next step is the appearance of a black dot, consisting of one or more pycnidia, in the center of each blotch. New pycnidia are formed soon in large numbers around the original one and the black dot becomes larger and larger until the whole blotch becomes black. In this stage the black spots resemble closely the teleutospore lesions of *Puccinia graminis*. Their form varies considerably. Often they are oblong or elliptic in shape and often take the form of short streaks or stripes (Fig. 2). These black stripes or streaks of pycnidia may be surrounded by a light yellowish colored line or they may border directly on the green and healthy tissues of the leaf. The blotches are visible on both sides of the leaves, but are somewhat larger and have more pronounced margins on the lower side of the leaves. Most pycnidia have their ostioles on the lower side of the leaves.

The infected leaves soon assume a light yellow color and die; in some cases they may preserve their green color until the ripening of the plants.

Simultaneously with the leaves, or shortly after, the leaf sheaths also show symptoms of the disease. The attack on the leaf sheaths, especially of the upper one at any time during the growing period, and before the heading out, in most cases leads to the complete destruction of the heads. While the fungus forms numerous pycnidia on the exposed leaf surfaces immediately after its establishment on them and remains localized, on the

leaf sheaths, at first at least, it forms no pycnidia, but spreads in the concavity of the sheaths and the enclosed young leaves, thus firmly binding together the upper central portions of the plant. The growing point of

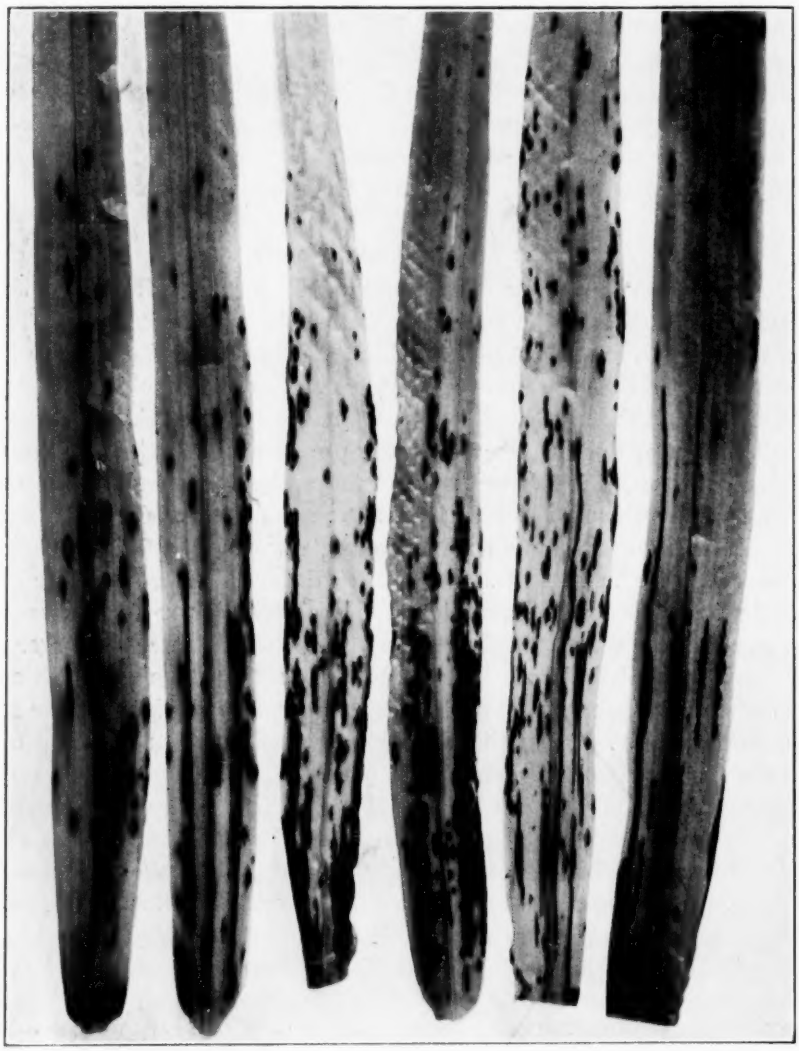

FIG. 2. Wheat leaves attacked by *Dilophospora alopecuri*. The blotches and stripes on them consist of pycnidia.

the plant thus firmly shut off on all sides, and still free from any fungus infection, but commonly surrounded by numerous nematode larvae, can never break through the leaf sheaths thus bound together and eventually

becomes a prey to the downward advancing fungus growth. In some cases the growing point pushing upwards against the bound together and partially or wholly killed upper leaves and leaf sheaths, and not being able to open a way begins to curl under its own pressure, filling up the cavity in which it finds itself firmly enclosed and forming a kind of knot (Fig. 1). Externally the upper portions of such plants resemble a cigar and have a spindle or conical shape. Often the increasing knot may succeed in breaking through the leaf sheaths, but its top, which by this time is also invaded by the fungus and firmly attached to the surrounding tissues, remains

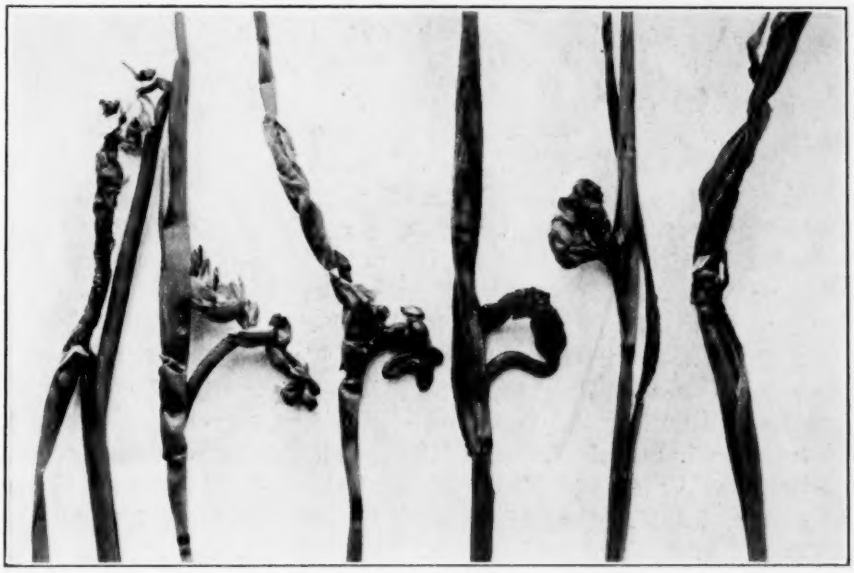

FIG. 3. Upper portions of fully grown wheat plants showing effects of *Dilophospora alopecuri* infection. The plants are deformed due to the gluing together of the young heads to the sheaths of the upper leaves.

within the sheath cavity. Plants so effected remain very small, fail to head out, and die quite early in the season. By far the largest number of infected plants belongs to this group. Some of the plants thus killed send out tillers from their bases, which usually remain free from the disease and develop normally, but ripen much later than the normal plants.

Plants on which the symptoms of the fungus infection appear somewhat later and after the formation of the second or third node, may also be deformed and killed in the same way as the above plants. This group of plants is the next largest. Where the symptoms of the disease appear shortly before the heading out of the plants the infected heads of the other-

wise normal plants may remain attached to the upper leaf sheath to which they are bound by the fungus growth (Fig. 3). Similar deformation of cereal plants can be brought about also by bacterial diseases (47). The kind of plants, however, which first attract attention upon a superficial examination of infected fields, are the otherwise perfectly normal plants, the heads of which are free but wholly or partially deformed and destroyed by the fungus. These are the plants least injured and last attacked by the fungus. The deformed heads look as if they had been pinched up into a

FIG. 4. Wheat heads showing various degrees of *Dilophospora alopecuri* infection. Infected portions are charred in appearance.

point when young and afterwards charred. The deformation of the heads may be partial, as already mentioned, the top being usually involved, or it may include the whole head (Fig. 4). Superficially the affected areas at first are white, being covered by a dirty, white, fungus growth, which later on becomes dark brown to black, resembling somewhat a sclerotium. The deformed head portions internally consist of a white mycelial tissue in which are embedded the glumes and rachis. The normal portions of the partially deformed heads are usually full of nematode galls, but they may in some cases form normal kernels.

The underground portions and bases of all infected plants are absolutely free from any pathologic changes and resemble in every respect those of the healthy plants.

DESCRIPTION OF THE CAUSAL ORGANISM

Taxonomy

Fries (9) in 1828 was the first to describe the fungus causing this disease under the name of *Sphaeria alopecuri*. Duby (7) described it several years later under the same name. In 1840 Desmazières (5), to whom as well as to Fries and Duby the original collector, Guepin, had sent part of his material, established the new genus Dilophospora[1] for this fungus and applied the specific name *D. graminis*, citing *Sphaeria alopecuri* Fr. as a synonym. Fries (10) in 1849 accepts Desmazières generic name, but insists upon his own specific name. The name of the fungus therefore should be *Dilophospora alopecuri* (Fr.) Fr. as Bessey (2) correctly pointed out. Fuckel (12) in 1861 described a similar fungus on *Holcus lanatus* under the name of *Dilophospora Holci* Fuckel, but changed this name in 1869 (13) to *Dilophospora graminis* forma *Holci* Fuckel. Fuckel and after him Saccardo (39), Ludwig (23, p. 318), Diedicke (6), etc., have described also an ascus and a conidal form of this fungus. So far the writer has never seen anything on the infected plants and artificial cultures of the fungus that could be taken for Dilophia or Mastigospora, the alleged ascus and conidial forms of Dilophospora. Störmer (50), Fron (11), etc., have expressed the same opinion.

Diagnosis

The diagnosis of the fungus given below is based upon the material gathered in the vicinity of Epen on wheat, rye and spelt, and upon artificial cultures and subsequent artificial infections made from the original material. A more extensive study of the fungus under different climatic conditions and on its various hosts may show that there are more than one Dilophospora species concerned with this disease.

The closely packed pycnidia, surrounded by numerous mycelia which are thick, short and rich in fat vacuoles, when examined with the lens, or in crossection under the microscope, seem to be embedded in a black stroma-like tissue as has been claimed by some mycologists. The pycnidia of this fungus however, as is shown by figure 5, lie completely free in the mesophyll of the leaves. This can be easily seen on leaves which have been decolorized by boiling in alcohol. On the leaf sheaths the conidia are formed in rows

[1] The name Dilophospora is composed of dis = double, lophos = comb, and spora = spore.

between the veins, quite uniformly scattered over the infected area, usually scattered but sometimes joined together in twos or threes.

The pycnidia are globose or elliptical, of a dark brown parenchymatous tissue, varying considerably in size, 120 to 300 μ, averaging 200 μ in diameter, thin walled, wholly immersed in the mesophyll of the leaf or leaf sheath, only the short papilla-like ostioles coming to the surface of the epidermis; pores 18–20 μ wide.

The spores are cylindrical, usually of same thickness throughout their length, only at the ends being somewhat constricted and ending in a number of hair or bristle-like appendages; the number of the appendages varies

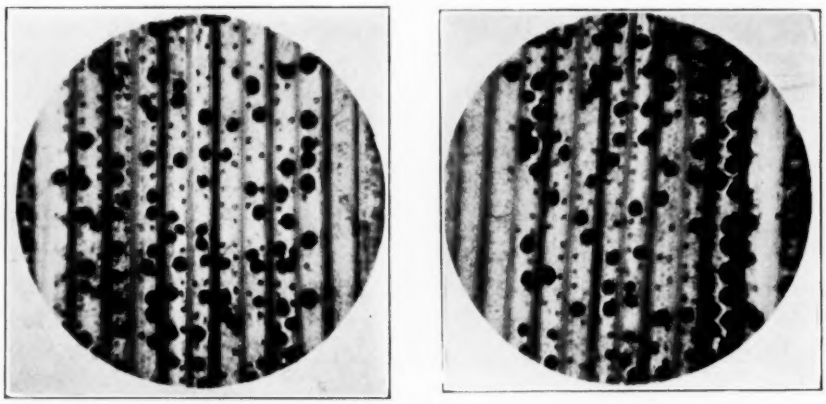

FIG. 5. Photomicrographs of portions of wheat leaves attacked by *Dilophospora alopecuri*, showing the pycnidia of the fungus. (Left) Upper side of leaf, the ostioles of some pycnidia are to be seen. (Right) Lower side of leaf. × 10.

from three to six and more. The bristles may be simple or branched and may come from one point in the form of a tuft or may appear subsequently on an axis, resembling somewhat the main branches of a tree. Spores usually are not distinctly septate. Distinct septation becomes apparent in the germinating spores (Fig. 6). In the fully developed young spores there are usually to be seen a number of small dense bodies of uniform size and very evenly distributed in one line over the length of the spores, sometimes they are in pairs. In mass the spores are light yellow in color. Exclusive of appendages the spores measure 8.5 to 15 by 1.6 to 2.5 μ, averaging about 12 × 2.2 μ. The appendages are 5 to 7, rarely 10 μ long and about 0.5 μ thick at the base.

PHYSIOLOGY OF THE CAUSAL ORGANISM

Cultural Characteristics

In general this fungus is a slow growing organism. Even under most favorable conditions it takes over a month to cover the surface of a slant culture. In the same length of time, in Petri dishes, it forms colonies of not more than 5–6 cm. in diameter. The fungus grows and fructifies best on rich, unfiltered hard oatmeal agar. Agar containing the whole content of the hulled oat kernels is much better than oatmeal extract. On the latter the colonies never attain any size and may fail to form pycnidia. Rich unfiltered, medium hard, cornmeal agar is the second best medium. The fungus grows and fructifies moderately also on plum decoction agar, malt agar, malt gelatine, carrot plugs, and potato agar, the last being the least suitable medium for this organism.

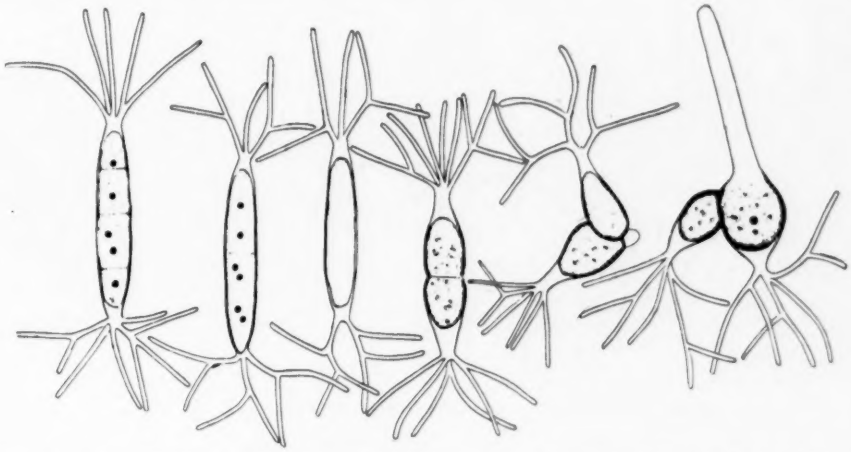

FIG. 6. Pycnospores of *Dilophospora alopecuri*. The three spores to the right represent various stages of spore germination. × 2000.

Mycelial growth is slow, at first only on the surface and quite loose, later and especially with the drying out of the culture there appears, in the cases where mycelia are used for transferring, a rich aerial growth, often forming large, irregularly round, comparatively dense tufts of mycelia. The aerial growth is in most cases, at first white or very slightly pink and may remain so for a long time; later the original growth takes a slightly grayish green to olive green color, which is primarily due to the formation of numerous pycnidia. The mycelium is of uniform thickness, sparingly branched and septated. With the appearance of pycnidia the aerial growth at the center of the colony disappears, the latter assuming a dark, olive green to black color. The aerial growth is scanty and fails completely when spores are

used for transferring. On rich and favorable media the fungus forms concentric rings of pycnidia, especially in Petri dishes. Pycnidia are usually formed on aerial mycelia or on the layer of mycelia lying on the surface of the medium, but may also be formed in the substratum, especially along the edges. On oat and corn meal agar when pycnospores are used for transferring, pycnidia are formed in abundance and almost without any mycelial growth, just as is the case on the infected leaves.

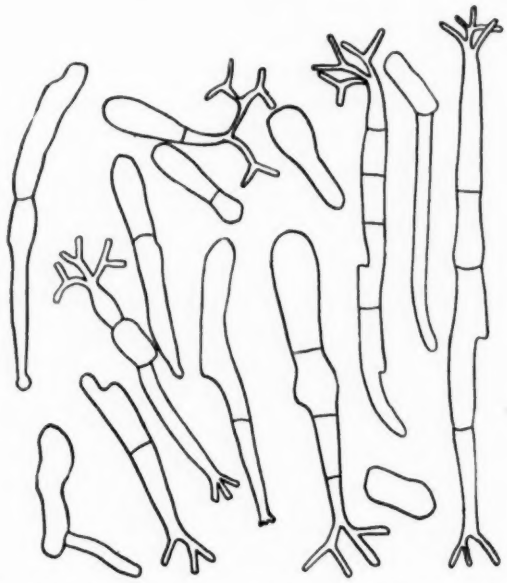

FIG. 7. Secondary spores of *Dilophospora alopecuri*. × 1000.

Spore Germination

The spores seldom germinate in water drops and not before the second or third day. On agar media they germinate in a shorter time and in much larger numbers. The germinating of the spores is preceded by a thickening of the cell walls and swelling of the middle portion of the spores; at the same time there appears a septum, dividing the spore in two parts. The swelling of the spores continues until they may reach twice their normal thickness. The swollen spore splits partially at the middle, so that the two halves stand to each other at an angle of from 60° to 45°. From the point of splitting there emerges a germtube (Fig. 6), which before reaching a length of 20–30 μ, forms one or more side branches. The end of the germtube stops growing further but sends out a number of shorter or longer appendages as seen on the spores and becomes itself a "secondary" spore. This also happens with the ends of the side branches. The young colony

continues forming secondary spores for a number of days. As a result there becomes apparent on the agar surface a small, light cream or pink colored colony, resembling in every respect a bacterial colony. A microscopic examination shows that what was originally a single spore now represents a pile of sporelike bodies, in most cases attached to some other sporelike body (Fig. 7). From this bacteria-like colony there appear afterwards in all directions mycelia, thus giving rise to a fungus colony. On Petri dishes the bacteria-like colonies, especially if numerous, may persist for a long time and even until the drying out of the plate. (Fig. 8.)

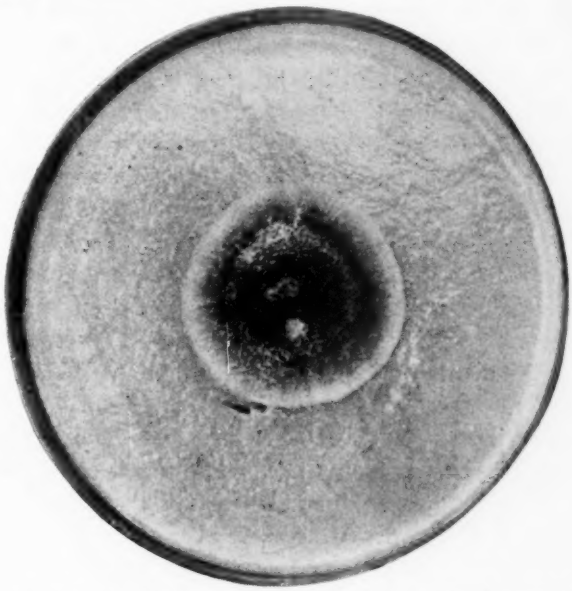

FIG. 8. 35 day old culture of *Dilophospora alopecuri* on oatmeal agar. 4/5 natural size.

Not all spores germinate in the way described above. In some cases the spore instead of becoming thicker begins to grow in length, the appendages of the one end disappear and it takes the form and the function of the germ tube. In still other cases only one-half of the spore swells, splits partially from the second half, from which point appears the germ tube, while the other half seems to undergo no changes; or the protoplasm from it may pass into the first half. In still other cases the appendages of a spore disappear at one end, from which point then appears the germ tube without being preceded by an elongation of the spore itself. In some cases after the swelling and partial splitting of the spore there come germtubes from both halves of the spore. In such cases the two spore halves break completely away from each other.

METHODS OF INFECTION

Infection Material

Abundant spore material of *Dilophospora alopecuri* for infection work can be obtained by growing the fungus on boiled wheat, barley or unhulled spelt. Steaming of the media in Erlenmeyer flasks each time for half an hour on three consecutive days is sufficient to sterilize it. The sterilization of the media should be so regulated as to prevent the splitting of the kernels and the formation of a compact mass of the media. There should be added just as much water to the flasks as the kernels will be able to absorb during the sterilization; the media should be porus. The greater the porosity, *i.e.*, the surface of the media, the greater the number of pycnidia will be.

Heavy spore suspensions can be obtained by macerating thoroughly the content of a flask or culture tube in a mortar, transfer then to water, shake up thoroughly and filter through a fine cloth or metallic sieve, let the starch settle for 10 minutes, and decant. The liquid so obtained contains millions of spores and can be used for infection experiments or for mixing with nematode suspensions.

The length of infection experiments can be shortened very much and positive results can be secured in all cases by using nematode suspensions instead of nematode galls. Under natural conditions the nematodes leave the gall only after the rotting away of its thick walls, whereas if the nematodes are freed from the galls by opening them, they can directly attack the plants. For securing a nematode suspension the galls are placed in a small cheese cloth bag, the bag is then immersed in water in a small beaker and allowed to stand for 12 hours. Care should be taken to keep the bag under the water, otherwise the galls will soon be overgrown by molds. The galls thus softened are then torn into pieces by means of needles and left to stand in the water for 12 more hours, to give the nematodes a chance to leave the galls. The suspension of nematodes then is poured through a fine metallic sieve to separate the gall fragments from the suspension. Such a suspension of nematodes contains also a great number of bacteria, fungous spores and protozoa. To a considerable degree the nematode suspension can be freed from these contaminations by diluting the suspension with water and leaving it to stand in a large Erlenmeyer flask until the nematodes settle to the bottom. The water then can be drawn out by a siphon. This should be repeated several times.

It is much more difficult to free the nematodes and nematode galls from the Dilophospora conidia. All nematode galls which the writer had at his disposal were obtained from a sample of grain which was simultaneously infected also by Dilophospora, so that both diseases appeared even in infection experiments where only nematodes were used. The writer was able

to obtain nematodes comparatively spore free by selecting only large, uninjured, shining, black galls that were free from fungus mycelia. Such galls were rinsed several times with sterile water, disinfected for 4 minutes in 1 per cent $MgCl_2$ solution, left to stand in distilled water for 4 hours, then torn open, freed from the nematodes, and removed at once from the water in which the nematodes remain.

Soil Infections

Quick and reliable infections with the nematode or Dilophospora disease can be obtained, if only the weather is warm, by infecting the soil with water suspensions of nematodes and Dilophospora spores. This can be done by infecting the soil at the time of sowing or after the emergence of the plants from the soil. For this purpose the writer made use in most cases of large pots. Pot infections have the advantage that the plants can easily be removed from one place to another; besides this the infection material remains limited to the pots. When the infection material is added to the pots at the time of planting, it is poured over the seed in the pots, the seed then is covered with a 2–3 cm. layer of fine, moist soil. In the cases where the infection material is applied to the young plants it is poured uniformly over them; over the plants is then sifted moist, fine soil so as to cover the surface of the soil on which the nematodes and fungus spores have been deposited. This is done to prevent an eventual drying out of the surface of the pots before the nematodes have had time to penetrate the soil or the plants.

All infected pots were kept constantly moist, because a drying out of the soil will naturally lessen the activity of the nematodes and may even delay or prevent the appearance of both diseases.

Wound Infections

If wound infections are ever to succeed they should be made at the vegetative point of the plants, though so far they have given no positive results.

The growing points of the plants can easily be located after the appearance of the first node. It stands about 1½ cm. above the uppermost node. The upper node, be it the second, third or fourth, can easily be located by feeling the culm of the plant between one's fingers. It lies deep under the several layers of leaf sheaths. Directly above it stands a still incompletely differentiated node followed by the vegetative point or rudimentary head of the plant. The two latter as already stated stand at a distance of about 1½ to 2 cm. above the well developed upper node. After locating the vegetative point, a split is made through the leaf sheaths and a drop of a heavy spore or nematode suspension is placed in the wound. The wound is then

tied up. Inoculation of the growing point can be accomplished much easier by injecting the spore or nematode suspension into the central cavity of the plant near the vegetative point. For this purpose the syringes used by medical men may be used.

PATHOGENICITY OF CAUSAL ORGANISM AND ITS RELATION TO TYLENCHUS TRITICI (STEINBUCH) BASTIAN

All of the several hundred wheat, spelt, and rye heads infected with Dilophospora, which the writer gathered in the province of Limburg during the summers of 1923 and 1924, upon a careful examination proved to be attacked also by *Tylenchus tritici*, and had numerous nematode galls in the portions that were free from the fungus. In the subsequent experimental work and field studies on this disease all Dilophospora infected plants showed also the presence of nematodes.

The same condition has been observed for the first time in a single case by Richon (34) in 1882. Störmer (50) in 1904 reports that without any exception all of the spelt plants sent to him from Pfalz were attacked simultaneously by *Dilophospora graminis* and *Tylenchus tritici*. Störmer also made the suggestion that probably the fungus, which commonly occurs on grasses, being not so well adapted to spelt, could get foothold only on those plants that are weakened by the attacks of nematodes. He observed that not all of the plants infected with nematodes were also attacked by the fungus. Bessey (2) found in 1906 nematode galls and Dilophospora pycnidia on the same leaves of *Calamagrostis canadensis*. Fron (11) in 1912 on the other hand reported that not all Dilophospora infected heads carry nematode galls and thought that the occurrence of the two parasites on the same plants may be only a coincidence. Stebler (49) *et al.* observed in 1917 in one case the occurrence of Dilophospora and Tylenchus on the same wheat and spelt plants and wrote that "Such a simultaneous occurrence of the two diseases is nothing unusual, especially on spelt." Pape (30) in 1921 also reported that a portion of the Dilophospora infected wheat heads sent to the Biologischen Reichsanstalt für Land- und Forstwirtschaft, Berlin-Dahlem, both from Baden and the Rhine province were also attacked by *Tylenchus tritici*. It may not be out of place to mention here that Maire (24), Marcinowski (25, pp. 67–116), and others have reported the simultaneous occurrence also of stinking smut, *Tilletia tritici* and *Tylenchus tritici*.

Though none of the above workers has suspected the existence of an intimate relation between these two diseases and while the up-to-date observations on the simultaneous occurrence of the two diseases on the same plants do not throw any light on the nature of this phenomenon, they never-

theless indicate that there must exist some relation between the two pathogenes.

It is well known that *Tylenchus tritici*, whose life history and parasitism has been extensively studied, is a true and highly specialized parasite (3, 4, 25), which can attack the susceptible hosts without the assistance of any external agents and in the absence of Dilophospora. Whether this applies also to *Dilophospora alopecuri*, which has never been studied, is not known.

At the hand of our present knowledge of the two parasites and the diseases caused by them it can be taken *a priori* as probable that this co-parasitism is not only of no use but even harmful for *T. tritici*, since it is evident that the nematodes can never form galls on the plants killed by the fungus or on the portions of the heads attacked by them, or if they should succeed to form any galls in these portions, the galls are overgrown and subsequently destroyed by the fungus.

Just how and whether this co-parasitism is beneficial to the second parasite will be shown further below.

Before doing this and in order to properly comprehend the way in which these organisms influence one another it will be necessary to review briefly the life history of *Tylenchus tritici*.

As is well known the above nematode forms numerous galls in the heads and sometimes also on the leaves of the infected plants. These galls, in each of which are present from 10 to 15 thousand living nematode larvae, fall on the ground during the harvesting of the plants or are carried into the soil with the seed. They can find their way back to the fields also by means of the manure, straw, animals, etc. Once in the soil and in the presence of moisture, the outer layer of the galls begins to rot or if injured in one or other way, their content is liberated. In the dry galls the nematodes are motionless and show no symptoms of life. In this condition they can survive twenty years. As soon as the gall and gall contents are moistened the nematodes become active and leave the gall shell, if this has been already ruptured or rotted away. Once free the nematodes move towards the nearest host plants and take a position in the concavity between the external and internal parts of the leaf sheaths of the young cereal plants. From here they advance further and further towards the center of the plant, moving always between the leaves until they reach the center, *i. e.*, the growing point of the plant, where they remain permanently as ectoparasites and where they are found in large numbers. With the growing of the plant they are pushed passively upwards by the growing point. As soon as the heads become differentiated and long before the heading out of the plants, the nematodes bore into the newly formed ovaries or around their bases.

The wounding and further stimulation of the host cells give rise to the galls, which are quite large and easily distinguishable when the heads emerge from the last leaf sheath. Usually a small number of nematodes are found in each newly formed gall; here they attain their full development and become sexually ripe, some male, others female. They then pair and lay a great number of eggs. From the eggs are soon hatched the young larvae, which after a short period of growing and with the ripening of the plants and drying of the galls become inactive, thus completing their life cycle.

In the writer's observations and infection experiments the Dilophospora disease, as already stated, appeared only on plants simultaneously attacked by the nematode disease.

The first symptoms of the Dilophospora disease, consisting of slight, silver green, blotches, appear on the uppermost leaf just as or even before its emergence from the sheath of the preceding leaf. The first, second, and in some cases even the third leaf, under natural conditions are as a rule never attacked by the fungus, and together with the base and underground portions of the plants remain free from the disease. Ranojewic (33, p. 398) also observed the disease only on the upper leaves.

The above facts throw an interesting light on the nature of this disease. The appearance of the disease first on the uppermost leaf shortly after or even before it has left the sheath of the preceding leaf and the freedom of disease of the lower leaves shows that the point from which the infection originates and spreads is the growing point of the plant itself. But how does the infection material reach the growing point of the plant without infecting the outer portions and the growing point of same?

All of the numerous infection experiments made with *Dilophospora alopecuri* alone gave absolutely negative results, in spite of the fact that infection experiments were made with wheat, spelt, and rye of various ages and of the same varieties on which the disease had been observed in nature; soil, seed, and wound infections at various temperatures and moistures of soil and air were also made, but the results were in all cases negative.

These results exclude the possibility that we have to do here with a fungus which attacks the plants in the way the smuts attack these plants or that this fungus behaves as some of the common plant pathogenic fungi.

Infection experiments in which wheat, spelt, and rye of different varieties were used and where the plants were infected simultaneously with *D. alopecuri* and *T. tritici* yielded in all cases positive and abundant Dilophospora infections even when comparatively large plants were infected. This showed that, regardless of whether the nematode attack on the plants makes them susceptible to the Dilophospora disease or not, the nematodes must certainly help in some way the fungus to reach the growing point of the plant.

From the life history of the nematode disease we know that from the soil the nematodes crawling and creeping between the leaf sheaths of the younger or older plants, reach their growing point. Under these circumstances it was natural to suppose that the nematodes carry the spores of Dilophospora to the growing point of the plants, where they subsequently attack the young leaves, though the way in which this is accomplished remained a question to be answered. Various experiments were made to establish this experimentally and if possible by means of the microscope.

For one of these experiments it was necessary to mix a water suspension of Dilophospora spores with a water suspension of nematodes. Immediately after the mixing of the two suspensions there appeared a heavy cottonlike precipitate in the container, while the liquid above the precipitate cleared up. A microscopic examination of the precipitate showed that it consisted of numerous nematodes, which were heavily loaded with Dilophospora spores, these having attached themselves to the nematodes by means of their bristles (Fig. 9), just as the seeds of some plants attach themselves and stick to our cloths, to the fleece of sheep or to the hair of other animals.

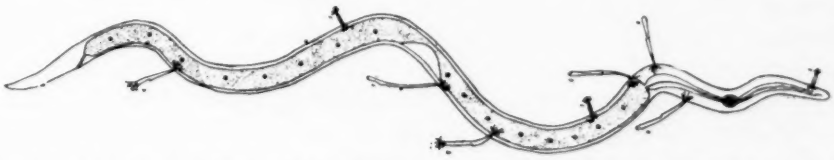

FIG. 9. Diagrammatical drawing of a larva of *Tylenchus tritici*. The larva carries a number of pyeno–[1] and secondary[2] spores of *Dilophospora alopecuri*, which have attached themselves to it.

The spores are attached so firmly to the nematodes that they cannot easily free themselves from the spores, and even if they succeed sometimes in doing so they pick up again other spores in their subsequent movements.

The above fact strengthened considerably the supposition that the nematodes are the agents which bring the Dilophospora spores to the growing point of the plants, which also the nematodes must reach in order to assure their further propagation.

The further work on this problem, however, showed that upon examining under the microscope on the growing points of the infected plants, consisting of minute leaflets or the young head, there were to be seen in most cases numerous nematodes. A more careful examination of these nematodes showed that they carried in most cases more or less numerous spores of Dilophospora. These spores were not the pyenospores which originally were applied together with the nematodes, but the secondary spores of the fungus, as observed in young cultures of the same. This condition can

be seen even before the appearance of the Dilophospora symptoms. This shows that the original pycnospores of the fungus with which the nematodes must have entered the plant have meanwhile germinated and have formed many secondary spores, just as they do in artificial cultures. The number of secondary spores found on the growing points of infected plants is often very large, so that they can be easily located upon microscopic examination of the vegetative point in water. With the advance of the fungus disease the nematodes die or leave the plants; this is especially true of plants severely attacked by the Dilophospora disease.

Examination of the otherwise perfectly healthy and normal growing points or rudimentary heads of a large number of plants infected naturally and artificially with Dilophospora showed the presence of nematodes which in all cases carried more or less numerous secondary spores of the fungus. In the examination of the plants for nematodes and spores all precautions were taken to avoid external contamination of the growing points during the opening and subsequent handling of them.

The finding of the spore carrying nematodes at the growing points of the young plants, diseased with Dilophospora and those infected but not yet diseased, confirmed the supposition that the fungus spores reach the growing point of the plants by means of the nematodes. But is this sufficient for the successful establishment and development of the fungus on the thus infected plants? If the nematodes do nothing more than merely deposit the spores of the fungus upon the tender and succulent growing point of the plants, it should be possible to infect plants with Dilophospora by depositing the spores of this fungus upon the growing points of the plants in a mechanical way.

About fifty wheat and rye plants in various stages of development were infected with Dilophospora by splitting the plants slightly just at or above the growing point and placing a great number of spores in the central cavity of the plants. The wounds of the plants were then closed and tied up. Other plants were infected by injecting in their central cavity a heavy suspension of Dilophospora spores. Still other plants were infected and reinfected in the above ways every other week, beginning as soon as they had their third leaf and continuing until they headed out. In all cases the plants failed to develop the disease.

Must it be concluded from this that Dilophospora alone can not infect even when present on the growing point of the plants? An absolutely positive answer to this question can not be given at this moment. The fact however that the Dilophospora diseased plants will recover fully from the disease if not already vitally injured, and produce perfectly healthy and normal leaves above the diseased ones as soon as the nematodes in them die,

leave them, or have formed galls, indicates that the relation between the two pathogenes is a more intimate one.

From the life history of the nematodes we know that they are pushed continuously upwards by the growing point of the plants, but we know from the morphologic development of the cereal plants that what has been a growing point a few days or even hours ago is now a leaf and that, if the nematodes did allow the growing leaves to push them upwards, they would soon come in this way outside of the plant. This however does not happen, because the nematodes desert continuously the newly differentiated leaves and move constantly downwards to the vegetative point, taking along also the Dilophospora spores. When the nematodes die or leave the plants, as pointed out above, it is natural that the Dilophospora spores which may have been deposited by the nematodes on the vegetative point, are thrown out with the differentiation and growing out of the new leaves. Thus the growing point of the plant and its whole central cavity are freed from the spores of the fungus. This explains why the leaves formed after the nematodes leave the plants, are free from the Dilophospora attack. The last fact can be interpreted also in the following way: The nematodes not only bring the Dilophospora spores into the central cavity of the plant and carry them subsequently back to the growing point of the plant from its growing out leaves, but the nematodes sucking or otherwise injuring or affecting the plants cells of the tender and minute leaves open the way for the penetration of the fungus into the cells and tissues of the young leaves and afterwards of the young head. This supposition seems to be supported also by the fact that, so far at least, all wound infections with Dilophospora have given negative results. That in the case of the wound infection the infection material has actually been placed on the growing point or the young head of the plants is shown by the fact, that a large number of the heads of such plants were deformed at the time they appeared from the leaf sheaths and some of them bore even the infection material (fractions of pycnidia and numerous spores) which had been placed upon them while still very small and lying deep in the sheaths. But none of the deformed and artificially infected heads showed any symptoms of the disease and were free from any fungus attack.

As is well known, the nematodes sometimes die or desert the weak, sickly or wilting plants; this they do also with the heavily Dilophospora infected plants. As soon as they leave the plants these recover, send out new leaves and even new tillers, if their primary stems have been killed by the fungus, which are free from the disease and may even form normal heads. This also happens when the nematodes bore into the young heads and form galls.

Though the boring of the nematodes into the floral parts of the young

heads lessens the danger of infection for the uppermost leaves, it must be the initial cause for the establishment of the fungus at last also on the heads. The top of the heads being the first to be formed is most commonly attacked by Dilophospora. The heads of plants severely attacked by the fungus are destroyed at an early date by the downward advancing mycelial growth from the bound together upper leaves.

As a rule the heads of Dilophospora infected plants, if ever formed, appear from the upper leaf sheath with distinct and prominent symptoms of the disease. Those which come from the sheaths free from the disease remain healthy.

The infected heads, as already stated, are not wholly destroyed by the fungus. In the apparently healthy portions of such heads are formed nematode galls and even normal kernels. The partially infected heads are, from the standpoint of the Dilophospora disease, of great importance because the nematode galls formed on them are often infected and overgrown by the fungus. Such galls thus became the carriers not only of the nematodes but also of Dilophospora. With the carrying of these galls to the fields planted or to be planted with cereals they give rise again to both diseases and thus complete the life cycle of both pathogenes.

The above fact explains why in the writer's infection experiments the plants to which were added no Dilophospora but only nematodes developed both diseases in all cases. The nematodes used in these infection experiments originated from a field that was attacked both by the nematode and Dilophospora diseases. At first it was thought that the soil must have been naturally infected with Dilophospora. The same experiments repeated on sterilized soil gave similar results. Further infection experiments in which only sterilized soil and only the nematodes from large, externally uninjured, black and shining galls, that were not overgrown by fungi, were used, yielded a smaller percentage of Dilophospora sick plants, than the check plants where the nematodes of average galls were used. These experiments show that in the above case at least some of the galls were infected by Dilophospora and that this is sufficient for the subsequent development of the Dilophospora disease.

For the simultaneous occurrence of the two diseases on the same plants in nature it is, however, not necessary that the nematode galls be infected with the fungus. In moist weather the spores of the ripe pycnidia leave the latter in the form of a thread or tendril, so that soon there appears over the infected area a very thick layer of spores. These spores germinate forming secondary spores so that the layer of spores becomes still thicker. It is highly probable that the nematodes after leaving the galls and while creeping around over the stubble in the fields must naturally come in con-

tact with such spores and take along some of them on their way to the plants.

A very slight contamination of the nematodes with spores of Dilophospora is not only sufficient but is a prerequisite for the appearance of the Dilophospora disease. Infection experiments where, to the nematode suspensions were added heavy spore suspensions, yielded in most cases absolutely disease free plants, *i. e.*, both diseases failed to develop on the infected plants. A heavy or even moderate contamination of the nematodes with spores is absolutely fatal for both diseases. Only such infections, where to the nematode suspensions were added very slight spore suspensions, yielded results. Severest infections of Dilophospora were obtained where no Dilophospora spores were added to the nematode suspensions. In such cases 100 per cent of all infected plants developed symptoms of both diseases and a microscopic examination of the vegetative points of the plants showed the presence of numerous nematodes, always loaded with secondary Dilophospora spores.

All galls which the writer had at his disposition, originating from fields where both diseases appeared simultaneously, were evidently infected by Dilophospora, because when used as infection material they produced in all cases both diseases. A microscopic and cultural study of the galls and the fungi present on them in no case established with certainty the presence of Dilophospora spores or mycelia on or in them. The great size of the galls and the many thousands of nematodes in them make it impossible to see under the microscope the whole content of a gall; on the other hand the very slow growth of this fungus makes it impossible to demonstrate its presence by plating or diluting the contents of the galls in agar, since the numerous other fungi which are usually present on the galls overgrow the plates long before the germination of the Dilophospora spores.

All efforts to secure Dilophospora free galls with viable nematodes were unsuccessful, so that important questions in connection with this problem must wait their solution until such material can be obtained.

CONTROL OF THE DISEASE

The nature of the disease in this case itself shows the way for controlling it: Preventing the nematode disease means also controlling the Dilophospora disease; which, as already pointed out, occurs only on plants infested by the nematodes.

Various chemicals and the hot water treatment have been recommended to control the one or the other of these two diseases, but in most cases they are not easy to apply or fail to give satisfactory results, while as regards the Dilophospora disease they have never been tried.

For controlling the nematodes the following measures have been used successfully and can be recommended.

Clean Seed

It is generally known that the main source of nematode and therefore of Dilophospora infection is the seed. For preventing both diseases it is therefore absolutely necessary to use clean seed, which is free from nematode galls and originating from fields where the diseases have not been present. Where this is not possible the seed should be freed from the nematode galls before sowing. This can easily be accomplished by the so-called sedimentation or salt-brine method. Byars (3, 4) used with success a 20 per cent common salt solution.

The seed is treated in the following way: First make up a 20 per cent salt solution by dissolving 20 Kgr. salt in 100 liters of water. Then pour the seed gradually into this solution, stirring vigorously at the same time. The sound wheat or rye kernels will sink while the nematode galls, light kernels, and trash, because of their lower specific gravity, will float. The floating galls and other contaminations are then skimmed off and boiled or burned to kill the nematodes. When upon further stirring of the liquid no more galls come to the surface, drain away the salt solution, which may be used repeatedly, and rinse at once in water. The treated grain is spread on the floor or a canvas to dry. The drying of the seed should be as rapid as possible, otherwise it may begin to germinate. The rinsing of the grain in water should also be done promptly, otherwise the viability of the grain may be injured. On account of this it is more advisable to use the same proportions of potassium chloride, instead of common salt, because when applied in the same way it does not injure the seed and, besides this, it can be used as a fertilizer after the treatment.

Spring wheat and rye treated both with salt and potassium chloride solution gave the germination results shown in table 2.

That a separation of the galls from the seed will eliminate both diseases was shown very conclusively in one of the writer's experiments, where three plots of 20 M^2 were sown with hand picked wheat, rye, and hulled spelt. All of these three kinds of seed were taken from a heavily infected mixture of wheat, spelt and rye. The three plots planted with hand picked seed, *i. e.*, with gall free seed, were perfectly free from both diseases. Whereas a fourth plot planted with the original mixture, developed both diseases in great abundance.

Sanitation

Besides with the seed, the nematode galls and nematodes may reach the fields with the straw or stable manure, or they may be brought over from

TABLE 2—*Germination of rye and spring wheat treated with a 20 per cent solution of NaCl and KCl. The treated seed was left at room temperature for 15 hours to dry and was planted in sand. Counts taken 15 days after planting.*

Number	Kind of seed	Treatment	Aftertreatment	Number of kernels	
				treated	germinated
1	Rye	no	no	400	254
2	"	H_2O	no	400	265
3	"	NaCl	no	400	188
4	"	NaCl	H_2O	400	226
5	"	KCl	no	400	214
6	"	KCl	H_2O	400	249
7	Spring wheat	no	no	400	301
8	" "	H_2O	no	400	292
9	" "	NaCl	no	400	265
10	" "	NaCl	H_2O	400	284
11	" "	KCl	no	400	274
12	" "	KCl	H_2O	400	328

infested fields to an uninfected area by means of the farm implements or surface water. Therefore no infested grain or straw should be used as animal food or the manure of animals so fed should never be applied to fields that are to be planted with wheat, rye or spelt. No surface water should be allowed to pass from infested to uninfested areas. A deep ploughing under of the stubble just after harvesting lessens the spread of the disease to nearby fields. Since most of the lighter galls are blown away in the straw during the threshing, it is highly desirable to burn up the straw of infested fields on the very place of threshing and as soon as this is finished.

Crop Rotation

Some of the nematodes present in the soil may fail to reach the plants and thus remain in the soil for a longer time, and a number of the newly formed galls must naturally remain in the fields after the harvesting of the crop. For this reason no susceptible crops should be grown on the same field for at least one year. Lengthening this period to 2 or 3 years will eliminate completely the disease. The larvae of *Tylenchus tritici,* contrary to those of most nematodes, can not remain alive for a long time in the moist soil, as Johnson and Leukel's (18) work shows, and die within a year, but it is probable that under certain conditions some of them may remain alive for a longer period of time.

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OBSERVATIONS ON BARK DISEASES OF CITRUS TREES IN SICILY

HOWARD S. FAWCETT

When passing through Italy and Sicily in May, 1923, the author had an opportunity to compare some of the bark diseases there seen with some of those he had previously been studying in California and Florida. Lesions which appeared to belong to the following bark diseases as now known in California were noted: Pythiacystis gummosis, decorticosis (shell bark), citrus blast and black pit on lemon trees, and psorosis on orange trees.

Pythiacystis Gummosis. Lesions with the characteristics of those produced by *Pythiacystis citrophthora* Sm. & Sm. in California were seen on orange and lemon bark in a few cases where trees were budded low. As has been pointed out,[1] however, lesions produced by this fungus cannot be told with certainty superficially from those produced by *Phytophthora terrestris* Sherb. The characteristic invaded patches of bark, killed to the wood, mineral brown at the cambium, surrounded by a yellow ochre gummous zone, the exudation of gum on the surface and the characteristic odor were all typical of either *Pythiacystis citrophthora* or *Phytophthora terrestris.* Most of the old lemon trees in Sicily at the present time are budded very high (sometimes 4 to 5 ft.) on sour orange (*Citrus Aurantium* L.) stocks, the bark of which stock is nearly immune to this disease. For this reason the lemon orchards are for the most part now free from this type of gummosis, although from 1863 to 1870 nearly all the trees (at that time mostly on other stocks) were killed by it.[2]

Decorticosis (shell bark). This disease was also observed frequently on old lemon tree trunks in a form quite similar to that occurring in California.[3] In California this disease is now thought to be due to a species of Phomopsis, *P. californica.*[4]

Many old lemon trunks showed the same cracking and shelling off of the outer bark in elongated strips as that seen here. The outer bark is killed and later in drying out it shrinks, warps and partly loosens from the inner portion which remains alive and builds up a new outer bark.

[1] Fawcett, H. S. Gummosis of Citrus. Jour. Agric. Res. **24**: 191–235. 1923.

[2] Savastano. Pathologia arborea applicata, p. 127–141. Napoli. 1910.

[3] Fawcett, H. S. California Citrograph. **9**: 330, July 1924.

[4] Fawcett, H. S. A new Phomopsis of Citrus in California. Phytopath. **12**: 419–424. 1922.

Citrus blast and black pit. These two manifestations of *Pseudomonas citriputeale*, citrus blast[5] and black pit,[6] were frequently seen both in Sicily and on the peninsula of Italy near Naples. On meeting Prof. Savastano at the Agricultural Experiment Station in Acireale, Sicily, it was found that he had already recognized the identity of the first one, citrus blast. The black pit was found on the fruit as a common accompaniment of the other. Both lesions were typical of those occurring in California. Recently Savastano[7] has mentioned both forms and thinks that the same organism is responsible for certain lesions on the trunk near the ground. Savastano reports that the citrus blast form of the disease has been in Sicily for a long time. Until recently it was not known by us[8] to occur outside of California.

Psorosis. This disease which is common to orange trees in both California and Florida, the cause of which is unknown,[9] was also seen on old orange tree trunks in a few places in Sicily and Italy. The symptoms all appeared to be the same as those for trees affected here. There was the same formation of irregular scales by the drying out and loosening of the outer bark, the formation of droplets of gum on the surface and an irregular semi-hypertrophied new tissue forming under the old loosened outer bark.

[5] Lee, H. Atherton. A new bacterial disease of citrus. Jour. of Agr. Res. 9: 108. 1917.

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PHYTOPATHOLOGICAL NOTES

Bibliography der Pflanzenschutzliterature.—The attention of American plant pathologists was called to this publication by Spaulding in 1921 (Phytopath. 11: 377). Although issued as an exchange journal Dr. Morstatt, the editor, reports few requests for it from American institutions. It has been issued in one volume annually since 1921. It appears to give a rather complete bibliography of the world's literature on the diseases and pests of plants for the year. It is not an abstract journal but the articles listed are fully and carefully cited, including full title in the original language. The papers cited are arranged according to a very convenient classification, being listed alphabetically by authors under each sub-division. This is a publication which every American plant pathologist and economic entomologist should have at hand as it presents in convenient form the year's output of literature in the field of plant protection, especially that of our European colleagues. This bibliography is issued by the Biologische Reichsanstalt für Landund Forstwirtschaft, Berlin-Dahlem. If your institution is not receiving this through regular exchange, you should see to it that it does so, for you are missing something worth while. The 1923 issue contains approximately 4,300 references.—H. H. Whetzel.

The Board of Agriculture for Scotland has just established a department of "Plant Pathology Investigation." Mrs. N. L. Alcock is the mycologist in charge. The new laboratory may be addressed at the Royal Botanic Garden, Inverleith Row, Edinburgh. Since this is the first time that an institution has been officially assigned to work upon mycology and plant diseases, the authorities will be very grateful for reprints and other literature on these subjects for their library.—Perley Spaulding.

ABSTRACTS OF PAPERS PRESENTED AT THE SIXTEENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, WASHINGTON, D. C., DECEMBER 30, 1924 TO JANUARY 1, 1925

Use of agar blocks for photographing living spores. C. D. SHERBAKOFF.

To keep living spores stationary and in one plane which is necessary for the best photographic reproduction a method was devised in which, for a study or photographing, the water-drop method was substituted by agar-block method. The blocks are cut out of agar sheets made by pouring clear agar between glass slides separated from each other by halves of very thin glass slides. The spore material is placed on a very clear cover glass into a small droplet of water and evenly smeared over it; the spores are allowed to become nearly dry, until the surface begins to look like that of a ground glass, and then turned over upon the agar block on the glass side. With this improvement long exposures can be made and a field selected where a great number of spores have arranged themselves in a desirable way.

Masuring water flow interference in diseased stems. I. E. MELHUS, J. H. MUNCIE and WM. T. H. HO.

A piece of apparatus has been devised for measuring the rate of flow in diseased and normal plant stem tissues. This apparatus consists essentially of a filter pump which exhausts the air from the system, a mercury column, a side delivery burette and a separatory funnel. These are so connected as to pull water or stains through stem tissues under at least one atmosphere of pressure. This apparatus, called a fluometer, makes it possible to measure the flow interference caused by *Bacterium tumefaciens, Fusarium conglutinans* and certain other gall and vascular parasites. Tests on 100 apple trees galled with *Bacterium tumefaciens* averaged 30 per cent reduced water flow. Cabbage plants infected with *Fusarium conglutinans* showed a partial or complete stoppage, depending upon the extent of the vascular invasion by the parasite. The normal cabbage stems averaged 16.02 c.c. flow in five minutes.

Cacao canker in Java. CARL HARTLEY.

Cacao canker is a red rot of the outer bark, which reaches the cambium only on the most susceptible trees. Its most rapid spread is tangential in the outer, and longitudinal in the inner, bark. *Phytophthora faberi* (?), which causes the disease, is difficult to isolate directly except from rapidly spreading lesions. It can be more easily obtained by using marginal canker tissue as crude inoculum in controlled wound inoculations on immature cacao pods; from the successfully inoculated pods the fungus is easily isolated. By removing the bark from cambium-killing lesions, sporulation can be induced on the underlying wood. In most countries the Phytophthora infections are reported more numerous in the pods than in the bark; in Java, on the other hand, cankers are often more numerous than rotten pods. Phytophthoras obtained from cacao differ decidedly from each other both morphologically and physiologically. The promiscuous cutting out of lesions appears to do more harm than good in Java, and the superficial shaving of lesions recommended by a number of writers is of very dubious value. The great variation in resistance of cacao to canker appears to be the key to the decrease of the damage from this disease.

The influence of temperature and of previous infection on the development of crowngall. A. J. RIKER.

The effect of temperature on the development of crowngall on aerial parts of tomato stems was tested in chambers where the air temperatures and moistures were regulated. Well developed galls were secured between 14° and 28° C. At 28–30° C. only poorly developed galls were produced and above 30° C. no galls appeared. The host plants made fair growth at these temperatures. At 8–10° C. the inoculated plants made practically no growth and produced no galls in a month.

The temperature relation of the causal organism was studied in nutrient dextrose agar, in modified Colley's medium, and in tomato broth. Although growth appeared over a much wider range, vegetative development was active only over the range of temperatures approximating that where galls were secured, *i.e.*, 14° to 30° C.

As others have reported, previous infection did not appear to influence crowngall development. A search for agglutinins or precipitins in plants which bore large galls, or in the galls proper, gave negative results. However, after the crowngall organism had been injected into a rabbit a serum was produced which possessed agglutinating properties in dilutions of 1 to 3,000.

Mottle-necrosis of sweet potatoes. L. L. HARTER.

In a brief article published in 1923 attention was called to a field disease of the enlarged roots of sweet potatoes called "mottle-necrosis," which was more or less widely dis' ibuted throughout certain sections of the country. It was pointed out that although a large number of attempts had been made to isolate an organism, plantings of necrotic tissue in agar plates either remained sterile or gave an occasional growth of Fusarium or bacteria. Since publication of the above article the disease has been located in new regions, indicating that it is probably spreading. By applying a special type of technique in the further study of this disease, the writer has been able to isolate a species of Pythium from the dead tissue in almost every case. It is believed that in view of the almost constant association of Pythium with the disease and of the results of some preliminary inoculations in the laboratory that Pythium is probably the causal organism.

Studies on the cytology of sugar cane mosaic. MEL T. COOK.

The white areas of infected leaves are thinner than the green areas or than normal leaves. Intercellular plasmodial bodies are frequently observed in the white areas. The nuclei in the white areas are more conspicuous than in the green areas or normal leaves because of protoplasmic masses. These masses may be spherical, irregular or elongated. The nucleoli are more numerous in the diseased than in the healthy cells and the chloroplasts are reduced in both size and number. Plasmodial bodies are found in all tissues of the stem except the very outer ones. They are always most conspicuous in actively growing parts, such as leaves that have just unfolded and in the parts of the stem just back of the growing point. They are not easily found in the older parts of the leaves or stems, or in old cankered canes. A disintegration of the walls of the internal cells of the canes is of very frequent occurrence, thus leaving protoplasmic masses, but the writer has been unable to associate plasmodial bodies with this condition. The presence of multi-nuclei and granular masses in the cells is not restricted to mosaic canes. The photosynthetic activity of the mosaic canes is greatly reduced.

Selecting for resistance to the sugar cane mosaic. C. W. EDGERTON.

By selecting plants showing very little effect of the mosaic in fields that have been 100 per cent infected for a number of years, strains have been obtained which show a

very high resistance to the disease. These strains have been carried through three years without losing their resistant characteristics. With a vegetatively propagated plant, this means either that bud variations are occurring or else that certain plants are acquiring an immunity to the disease.

Geographical distribution of the milkweed flagellate, Herpetomonas elmassiani (Migone). Its non-pathogenicity in Maryland. FRANCIS O. HOLMES.

The flagellate inhabiting the latex of the milkweed *Asclepias syrica* L. was most widespread during September and early October. At that time a search was made for the northern limit of its range along the Atlantic coast.

In Maryland the flagellates were as common as they were last year. They could be traced north as far as the New Jersey bank of the Hudson River. But five hundred milkweeds collected in Massachusetts, and an equal number collected in Yonkers, N. Y., were negative. On the coast the normal limit for *Herpetomonas elmassiani* (Migone) in milkweed seems to be northern New Jersey.

In Maryland heavily infected and uninfected plants growing side by side were indistinguishable in total height, in color, and in the number of seed pods produced. Though they were under observation from June to September it was not possible to predict which plants were positive and which negative without a microscopical examination of the latex for organisms. Apparently the plants were capable of supplying abundant food to the flagellates without limiting their own growth.

Effect of intermittent temperatures on potato mosaic. C. M. TOMPKINS.

It has already been shown by Johnson that constant exposure to temperatures above 24° C. masks potato mosaic and that lower temperatures favor mosaic symptoms. Experiments in constant air control chambers now indicate that relatively short exposures to the higher temperatures are sufficient to completely mask mosaic. Mosaic plants placed for 9 hours at temperatures above 24° C. but remaining at temperatures favorable for mosaic for 15 hours recovered in 7 days. Mosaic plants exposed for only 2 hours at 28° C. but at favorable temperatures for mosaic for 22 hours practically recovered in 28 days. At 40° C., however, a 2-hour exposure gave recovery in 7 days, and a 6-hour exposure enabled recovery to occur in 4 days.

At temperatures above 24° C., new leaves produced are not mottled or crinkled but are a uniform dark green, lacking all symptoms characteristic of mosaic. Masking often seems to be associated with stimulated chlorophyl production. The lower or older leaves with distinct symptoms may or may not lose their mottling and crinkling completely, depending upon the age of the leaves, upon the duration of exposure, and upon the temperature to which exposed at or above 24° C. In plants where mosaic was masked by high temperature, characteristic symptoms were again induced by exposing the plants to favorable low temperatures.

A virus from potato transmissible to tobacco. JAMES JOHNSON.

Symptoms of disease can be obtained on tobacco plants inoculated with extract from mosaic potato foliage. These symptoms are distinctly different from tobacco mosaic and are generally characterized by faint mottling or irregular necrotic areas. Whether or not this disease is potato mosaic on tobacco is not easily determined. Other potato degeneration diseases and, as far as can be determined, healthy potato foliage usually yields the same symptoms as mosaic potato foliage.

A combination of potato mosaic and tobacco mosaic virus on tobacco produces another symptom, different from either one alone. Leaf spots and blotches, sometimes

killing entire leaves, normally occur, whereas such symptoms do not occur with tobacco mosaic alone in the controls. Similar results were secured on tomatoes.

The causal agent of both the single and the combination symptoms on tobacco can be transmitted repeatedly from tobacco to tobacco.

Either potatoes free from this virus are rare or else extract from healthy potato foliage may cause a physiological disturbance of tobacco and tomato plants, which is of an infectious nature. Assuming the latter, it suggests some interesting possibilities as to the origin of virus diseases.

The Fusarium Conference. C. D. SHERBAKOFF.

The subject in general will be covered also in a paper prepared by the members of the conference. The conference met in Madison, Wisconsin, early in June, 1924, and continued for two months. The following members regularly attended it: Dr. H. W. Wollenweber, from Germany; Dr. Otto Reinking, of the United Fruit Company, and Dr. Helen Johann and Mrs. Alice Bailey, of the Bureau of Plant Industry, and myself temporarily employed for the purpose by the Bureau of Plant Industry in cooperation with the Tennessee Experiment Station. Dr. Wolllenweber was employed by the United Fruit Company to study Reinking's Fusaria, and the rest of us to increase our knowldege on the subject. Besides the identification of Reinking's Fusaria by Dr. Wollenweber, the conference prepared a paper on "Fundamentals for taxonomic studies of Fusarium," revised the names in "Fusaria of Potatoes," defined Lisea section and subsection Ferruginosum, made a revision of section Elegans, and examined certain special sets of cultures of Fusaria. The significance of the conference lies in its international character and in the earnest cooperation of a commercial enterprise and several public institutions in a purely scientific subject.

Leaf-spot of maize, a disease distinct from leaf-blight. CHARLES DRECHSLER.

Longitudinally elongated buff lesions on maize leaves from Florida and the Philippines, typically much smaller and more numerous than those of leaf blight, and often delimited by the veins of the host, have been found due to a species of Helminthosporium distinct from *H. turcicum* Passerini, differing from the latter especially in its strongly curved, elliptical conidia being more narrow, more abundantly septate, only slightly tapering from the middle, and provided at the base with an internal scar rather than a protruding modification. Discrete, subglobose, distinctly beaked perithecia developing subcylindrical short-stipitate asci with typically 4 fuliginous, filamentous, 5-to-9 septate spores disposed in a close quadruple heterostrophic spiral, each spore usually making 4 turns, are abundantly produced. Under experimental conditions the fungus is violently pathogenic to maize but causes only incipient lesions on rice and sugar cane. The morphological difference between the ascigerous stage and Pyrenophora or Pleospora supports the view that the species of Helminthosporium with straight subcylindrical conidia germinating laterally from end and intermediate segments, constitute a natural group distinct from the large group of species, which like the leaf-spot parasite, produce curved elliptical conidia germinating by two polar germ tubes.

Tabulation of the genera Phoma and Macrophoma. P. A. YOUNG.

This paper consists of a tabulation of the species of Phoma and Macrophoma given in Saccardo's "Sylloge Fungorum" and most of the more recently described species. The arbitrary difference between these genera has not been well observed. They intergrade with Phyllostieta, Dendrophoma and Septoria. The species are tabulated in the

order of their minimum spore lengths and further arranged in the order of maximum spore lengths. The tabulation contains a reference to a description of each species, sizes of pycnidia, ranges of spore lengths and widths, family numbers and host genera. The columns of family numbers and generic names serve as a host index. Phoma is probably the largest genus of plants. The tabulation contains 1,563 species of Phoma and 314 species of Macrophoma; 148 species being omitted because their descriptions lacked spore lengths. The existence of 612 species with minimum spore lengths between 3 and 5 microns points out one of the repelling difficulties of classifying species of Phoma.

Cytological studies of crowngall tissue. A. J. RIKER.

Comparisons of cells which developed in tomato plants after infection by crowngall bacteria, and after wounds, have shown a progressive reduction in the sizes of the cells and nuclei, and in the nucleo-cytoplasmic ratio to a minimum from which there was a slight return. The minimum was reached more quickly by the wound tissue than by the gall tissue. Several types of inclusions were observed in different kinds of crowngall cells. In tomato galls no clear evidence was found that nuclear division occurs by amitosis or that more than one nucleus appears in an individual cell. As others have observed, secondary thickenings in the walls first appeared among the smaller and more active cells. There seems to be a close similarity between the cells in crowngall and wound tissue.

Sweet potato varieties that produce well and are resistant to stem rot on sassafras sands. R. F. POOLE.

By testing a large number of sweet potato varieties and strains in New Jersey on sassafras sands infested with *Fusarium batatatis* and *F. hyperoxysporium*, three varieties were found to be resistant to the stem rot disease and to yield well on most of the infected soils where the native Jersey varieties were grown at a loss due to heavy kill by the disease. The results obtained with the Red Brazil, the White Yam and the Triumph varieties have made a very favorable impression on many growers. Seed, especially of the first two varieties, has already become widely distributed in this state where herebefore only the Jersey varieties were grown for commercial purposes.

The relation of soil moisture to the pox disease of sweet potatoes. R. F. POOLE.

Feed and edible roots of the Vineless Yellow Jersey variety of sweet potatoes were severely infected by *Cystospora batatae*, the causal organism of the pox disease, when grown in infected soil maintained at 4 and 6 per cent moisture. At 8 and 10 per cent moisture the edible roots were not attacked, but the feed roots showed a large number of poxed spots. At 12, 14 and 16 per cent the infection was very slight, while the maximum productions of both raw potatoes and total dry weights were obtained. At 18 per cent (soil saturation) there was no infection. These results explain the data obtained from field observations, which showed that the pox disease was so severe in dry seasons that it often resulted in a failure of the crop, while on the same soil the disease was much less severe and the crop a success in wet seasons.

Second progress report of black rot (Pseudomonas campestris) investigations on Long Island: seed infection and seasonal development. E. E. CLAYTON.

In greenhouse experiments cauliflower seed plants, spray inoculated, developed pod lesions in seven days, while the incubation period for succulent young plants was 13

to 15 days. Inoculations of seed pods of cabbage and Brussels sprouts were also successful. The organism remained alive for three years in naturally infected seed.

Infected seed sprouted normally, the disease first appearing as a cotyledonary lesion from which bacteria spread into the main stem. Progress up and down the stem was slow and infected plants appeared normal at time of transplanting. The first field symptom was the wilting of one or more lower leaves. This was followed by secondary spread which was most intensive in the immediate neighborhood of primary infected plants.

With cauliflower the major portion of secondary infection took place directly thru the uninjured lower leaf surface. Following favorable weather individual leaves showed 100 or more lesions. Such infections occurred also commonly on Brussels sprouts and occasionally on cabbage.

Stringent protection against all insects did not check the spread of the disease. The principal agencies of dissemination were rain and plant contacts incident to cultivation.

Second progress report on seed treatment for black leg (Phoma lingam) and black rot (Pseudomonas campestris) of cruciferous crops. E. E. CLAYTON.

In 1924 seven lots of infected seed (three infected with black rot and four with black leg) of cauliflower, cabbage and Brussels sprouts was used. Each treatment was represented by separate seed bed and field plats.

Hot water treatments of 14, 16, 18, 20, 25 and 30 minutes at 50° C. gave good, but not complete, control of black leg and, with one exception, complete control of black rot.

Seed treatments with Uspulun 0.25 per cent for 0.5, 1 and 2 hours; Semesan 0.25 per cent for 0.5, 1, 2 and 4 hours; $HgCl_2$ 0.1 per cent for 0.5 hours; and HgI_2 0.05 per cent plus KI 0.1 per cent for 1, 2 and 4 hours all gave unsatisfactory control of both diseases.

In experiments with one lot of seed infected with black rot, Germisan 0.25 per cent for 0.5 and 2 hours, and $Hg(CN)_2$ 0.1 per cent for 1 hour gave complete control but the latter much reduced germination.

Dust, Dupont No. 13 (an organic compound of mercury) gave excellent control of black leg but was completely ineffective against black rot.

Alternaria Solani as a cause of tuber rot in potatoes. DONALD FOLSOM and REINER BONDE.

The fungus was isolated from lesions in tubers taken from commercial storage in different years and places. The lesions were distinctive, being darker than the healthy skin, somewhat sunken, and surrounded by a slightly raised border which was circular or irregular in outline. A typical lesion is shallow, rarely exceeds a centimeter in diameter, and is easily removed apparently because of being limited by a new cork layer. With the isolated cultures positive results were obtained from the inoculation of young tubers and of foliage of greenhouse plants. The fungus was reisolated from the tubers and used for successful reinoculations. Immature tubers packed in diseased foliage secured from the field became badly infected and all attempts at isolation from these tubers gave pure cultures of the fungus. It is thought that under Maine conditions the chief loss involved with this type of rot is due to secondary infection. In two lots, one culture in about every ten was incapable of producing the usual reddening of potato agar, though the spores and infectiousness were normal, indicating the existence here of a saprophytic rather than parasitic difference between biological strains.

Drop of Chinese cabbage and common cabbage. W. H. DAVIS.

In the late summer and autumn of 1923, sclerotia were observed on diseased Chinese cabbage (Petsai, Chokurei, Wong Bach, Kinshiu, Chosen) and our common cultivated cabbage (Danish Baldhead) growing in the gardens of the Massachusetts Agricultural College at Amherst. The writer has not observed in literature any previous reference to this disease on Chinese cabbage.

Mycelium and apothecia were cultured from the sclerotia and measurements of their parts showed the fungus to be morphologically identical with *Sclerotinia sclerotiorum* (Lib.) Massee. (*Sclerotinia libertiana* Fckl.) which causes lettuce drop.

While a *Botrytis sp.* was isolated from and grew abundantly on dead portions of Chinese cabbage, it was not associated with the life cycle of the Sclerotinia.

Inoculations within the host species and reciprocal inoculations of Chinese cabbage (*Brassica Pe-Tsai* Bailey), cultivated cabbage (*Brassica oleracea* var. *capitata* L.) and lettuce (*Lactuca sativa* L.) gave positive results.

Teratological forms were observed in which the margins of the apothecia formed secondary apothecia by proliferation.

Dusting celery seedbeds to control blights. A. G. NEWHALL.

Both the bacterial blight (*Pseudomonas apii*) and late blight (*Septoria apii*) have frequently been found on plants in the seedbeds. It has been shown that dusting the seedlings from 2 to 4 times with 20–80 copper-lime dust at about weekly intervals before transplanting them to the field has greatly reduced subsequent development of blights. From 4 to 20 times as much blight has been found later in the season on plants from the untreated portions of the seedbeds. Increases in yields of from 25 to 100 crates per acre have beeen obtained by dusting the seedbed or by locating the seedbed on new muck to insure blight free plants for transplanting.

The significance of the 1924 outbreak of western yellow tomato blight in the United States. MICHAEL SHAPOVALOV.

Western yellow blight of tomatoes was exceptionally severe in the summer of 1924 in several widely separated regions of the country. It destroyed nearly 100 per cent of the crop in one locality in California and about 30 per cent of the total commercial crop of the state of Utah. Moreover, it was during that season that it was for the first time reported east of the Rocky Mountains where heretofore its occurrence has not been known. This unusual outbreak of the disease was due to a peculiar combination of climatic factors which tended to produce a high rate of evaporation. In those localities where the amount of blight was greater than ordinary, the rate of evaporation was decidedly higher than the normal; and vice versa, in the localities where the disease appeared in the usual percentage, the rate of evaporation was about the same as usual.

The blossom-end rot of pepper. B. B. HIGGINS.

In a previous publication (Ga. Exp. Station Bul. 141: 61–62) a disease of pepper, *Capsicum annuum* L., was described and tentatively ascribed to physiological causes, principally variations in moisture supply. This conclusion was based upon field observations and the fact that no organism was found in the tissue of newly formed spots.

During the last two years blossom-end rot has been repeatedly produced experimentally by manipulation of the water supply. In general terms, lesions develop near the blossom end of young, rapidly growing, pepper fruits when transpiration is high and soil moisture not sufficient to supply the needs of the plant. A histological study of

young spots has shown that they are initiated by a collapse of large cells about the ends of the small veinlets which are abundant near the blossom end of the fruits.

The variety as a unit in studies of disease resistance. L. J. STADLER.

Determinations of varietal resistance to disease imply the assumption that different stocks of an agronomic variety are practically equal in resistance to a specific disease. Percentages of infection were determined in the seasons of 1922–1923 and 1923–1924 in 50 stocks of Fulcaster wheat inoculated with *Tilletia laevis* and in 57 stocks of Kherson oats inoculated with *Ustilago laevis* and with *U. avenae*. The stocks of each variety were taxonomically pure and identical, and were obtained from seedsmen and experiment stations in different parts of the United States. In all cases marked differences in the percentage of infection between different stocks of the same variety were found. Conclusions regarding varietal susceptibility may often be in error, because the stocks tested do not represent the varieties in which they belong. The results of a disease resistance test may properly be applied only to the strains actually tested.

Inheritance of disease resistance in wheat and oats. E. F. GAINES.

Recent literature is reviewed showing that commercial varieties of farm crops vary greatly in resistance to their major diseases. When resistant or immune varieties are crossed with susceptible ones, resistant and susceptible segregates are obtained in the F_2 generation which breed true in subsequent generations.

In testing more than five hundred varieties and selections of wheat in respect to resistance to bunt, during the past ten years, the author finds variations from immunity to complete susceptibility. Crossing varieties and testing the progeny in subsequent generations has shown that resistant wheats may carry different factors for resistance which are cumulative in effect. From one such cross an immune variety has been produced which has sufficient merit for commercial production.

In testing two hundred and eight varieties of oats for resistance to covered smut, twenty-three were found to be immune. When the immune Red Rustproof was crossed with four varieties of varying susceptibility, a large percentage of the F_2 families were immune. Hull-less segregates occurred which could not be induced to produce smutted panicles, although the Nuda group has always been considered very susceptible.

Resistance in wheat seems to be recessive but dominant in oats. Both can best be interpreted on the basis of multiple factors.

The control of loose smuts of wheat and barley, and barley stripe by Uspulun, Semesan, and Germisan. H. A. RODENHISER and E. C. STAKMAN.

Uspulun (0.25 per cent sol.), Semesan (0.3 per cent sol.), and Germisan (0.25 per cent sol.) controlled loose smuts of wheat and barley, and barley stripe when the seed was soaked at 45° C. for one hour or longer. About seven per cent of heads in control plats were smutted, while there was only a trace of smut in the treated plats. The percentage of plants affected with stripe was reduced from thirteen per cent to less than one per cent. Germisan also practically eliminated stripe when seeed was soaked for three hours at ordinary temperatures. Shorter periods of immersion were not effective. Hot Germisan injured the seed slightly.

A leaf-spot of redtop caused by an apparently undescribed species of Helminthosporium. CHARLES DRECHSLER.

During July, 1923, in the vicinity of Washington, D. C., the foliage of redtop (*Agrostis alba* L.) was found spotted with elongated dead regions dull reddish-gray in

color. At first small, these lesions later often attained a length of over 10 centimeters, thus involving considerable portions of the leaf blade. From the central portions of the affected regions, conidiophores typical of Helminthosporium were found to emerge, bearing straight, cylindrical, olivaceous, 1-to-9 septate conidia, germinating by the production of lateral and oblique germ tubes from end and intermediate segments. In pure culture, sporulation in moderate quantity may be obtained, often with meager development of aerial mycelium, and production of numerous small sclerotia, thus in the latter details differing from the congeneric parasite causing purple leaf-spot of oats, the conidial condition of which it closely resembles. It differs from *H. siccans* Dr. in the inferior dimensions of its conidia and in pathological habit. The fungus appears to be of widespread distribution, having been previously collected on Long Island and in Connecticut, the collections, however, lacking clear evidence of parasitic relationship owing to frequent withering of redtop foliage from other causes.

Relation of internal cob-discoloration to yield in corn. (Second progress report). R. A. JEHLE, F. W. OLDENBURG, C. E. TEMPLE.

Seed corn was carefully selected for quality and type. The butts and tips were chopped off, and the seed ears were divided into at least two lots, those which showed red, gray and other abnormal internal cob-discoloration, and those which were practically free from internal cob-discoloration. Yield records were obtained from plots grown from each lot. These records show an apparent correlation between internal cob-discoloration and yield, which was more pronounced on light sandy and clayey soils than on the best corn land. This is indicated in the following table:

Year	No. of tests	No. of counties	Av. yield of corn from discolored cobs	Av. yield of corn from cobs with no discoloration	Average increase bushels	Average increase per cent
1921 Total	6	4	39.57	51.46	11.89	23.1
1922 Total	39	16	57.86	67.19	9.33	16.12
1923 Total	24	13	56.80	63.58	6.78	12.00
1924* Total	16	11	45.20	53.59	8.39	18.56
1921 VG**	1	1	60.4	63.3	2.9	4.8
1921 MP***	5	4	35.41	49.13	13.72	38.77
1922 VG	9	3	84.16	88.81	4.65	5.5
1922 MP	30	15	51.39	60.86	9.47	18.43
1923 VG	3	2	78.25	80.25	2.00	2.55
1923 MP	21	11	53.74	60.99	7.25	13.50
1924* VG	2	2	61.57	63.45	1.88	3.05
1924* MP	14	10	42.86	52.17	9.31	21.95

*(1924) Record incomplete, **(VG) Very good corn land, ***(MP) Medium to poor land.

Foot and root rots of wheat in Minnesota in 1924. J. J. CHRISTENSEN and E. C. STAKMAN.

In Minnesota in 1924, foot and root rots killed from 2 to 4 per cent of the plants of common wheat, and from 5 to 15 per cent of plants of durum wheats after heading. Seedling injury is not included. In many fields of durum 20 to 30 per cent of plants were killed, and in several as many as 75 per cent succumbed. More than seven hundred isolations were made from diseased plants. *Helminthosporium sativum* was obtained from 71 per cent of the platings; Fusarium spp. from 22 per cent, and other fungi from 7 per cent. One hundred and four varieties were grown on sick soil at University Farm, St. Paul. These included durum, club, emmer, spelt, poulard, polish, and vulgare wheats. All species and varieties were attacked, but in different degrees. The durums were most susceptible. The average percentage of killing in fourteen varieties of durum was 78; and in seventy-one varieties of vulgare wheats, 9.9 per cent. The average percentage of killing for all varieties was 20.1.

The control of flax rust. A. W. HENRY and E. C. STAKMAN.

Flax rust (*Melampsora lini* (Pers.) Desm.) may practically ruin a crop for fiber purposes and may also reduce the yield of seed. Several immune or highly resistant seed-flax varieties have been found. Numerous strains of large-seeded, blue-flowered Argentine flax are immune and some also are wilt resistant. Ottawa 770B, a yellow-seeded, white-flowered variety, also is apparently immune. Several other seed types are either resistant or immune. Rust resistance and wilt resistance are not necessarily correlated. Winona is wilt resistant but susceptible to rust, and rust-immune strains of Williston Golden are particularly susceptible to wilt.

As our good fiber varieties like Saginaw, and seed varieties like Winona, are susceptible to rust, these have been crossed with the immune seed types. Rust resistance appears to be dominant, and segregation in the F_2 indicates that immunity can be combined with the desired morphological characters.

No infection of seedlings resulted from inoculating flax seeed with viable urediniospores before sowing, but successful infection did occur when bits of telia were mixed with the seed. Obviously thorough cleaning of the seed is advisable. Crop rotation and early seeding are also important preventive measures.

(Cooperative investigations between the Office of Cereal Investigations and Office of Fiber Plant Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, and the Minnesota Agricultural Experiment Station.)

Factors affecting the development of Melampsora lini (Pers.) Desm. HELEN HART.

Aeciospores and urediniospores of *Melampsora lini* (Pers.) Desm. germinate in distilled water at temperatures ranging from 0.5° C. to 27° C., the optimum being about 18° C. They germinate equally well in light and darkness. Host tissue did not stimulate germination appreciably. Teliospores require a rest period which could not be shortened artificially. Urediniospores may begin to germinate within one and one-half hours and only three hours in the moist chamber are required for infection. Uredinial germ tubes enter through the stomata of resistant as well as susceptible varieties. Under favorable conditions uredinia are formed in about nine days. Light hastens their formation, while darkness retards it. Uredinia are formed at temperatures ranging from 7° C. to 30° C. The effect of nutrients is indirect, intensity of infection being directly proportional to luxuriance of growth of the host. Rust from common flax infected *Linum rigidum* but not *L. lewisii*, while that from *L. lewisii* did not infect common flax.

(Cooperative investigations between the U. S. Department of Agriculture, Bureau of Plant Industry, Office of Cereal Investigations, and the Minnesota Agricultural Experiment Station.)

Alternate hosts of Puccinia coronata Corda. S. M. DIETZ.

In a further study of the alternate hosts of *Puccinia coronata* Corda, the response of the four genera, Berchemia, Ceanothus, Zizyphus, and Rhamnus, of the family Rhamnaceae, has beeen determined. *Berchemia scandens* produced aecidia when exposed to infection from teleutospores on *Avena sativa*. *Ceanothus americanus* and *Zizyphus lycioides* gave negative results with the specialized forms on Avena, Calamagrostis and Festuca.

The response of five additional native and two European species of Rhamnus was also determined. *Rhamnus dahurica, R. ilicifolia, R. pachyphylla, R. pinetorum, R. rubra,* and *R. tinctoria* produced aecidia with the specialized form, Avenae. *Rhamnus pinetorum* and *R. rubra* produced aecidia with the specialized form on *Calamagrostis canadensis,* while only pycnidia were produced on *R. dahurica, R. pachyphylla,* and *R. tinctoria.* Teleutospores on *Festuca elatior* produced aecidia on *R. rubra.* Although *R. nevadensis* gave negative results from teleutospores on all three gramineous hosts, further trials are necessary to firmly establish its resistance.

No increase in degree of infection on *Rhamnus frangula* during 1923 and 1924 was obtained. Intensive field surveys conducted in 1923 and 1924 disclosed no aecidial infection, thus corroborating the earlier suggestion that *Puccinia coronifera* Kleb. is absent from America.

Although the genus Lepargyraea was exposed to infection with teleutopores on Avena, Calamagrostis, and Festuca, only *L. canadensis* produced aecidia from teleutospores on *C. purpurascens.*

(Cooperative investigations by the Iowa Agricultural Experiment Station and the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.)

The inheritance of resistance to Puccinia graminis avenae. S. M. DIETZ.

Inheritance of resistance to *Puccinia graminis avenae,* Form 2, was studied by artificially infecting the F_1, F_2, and F_3 generations of crosses between eight pure-line varieties of oats, studied from 1919 to 1923 under field and greenhouse conditions, using percentage of infection and size of uredosori as a measure of resistance or susceptibility. Resistance was dominant and based on a single factor difference in the National × White Tartar and Lincoln × White Tartar crosses.

Three genetically-different susceptible Burts were found. At least two factors, one an inhibitor, were involved. In a Burt × White Russian cross, the F_1 was susceptible and the F_2 segregated into 58 resistant to 251 susceptible plants. The resistant F_2 plants segregated into one homozygous resistant to two heterozygous families. In the second Burt × White Russian cross, the F_1 was susceptible, the F_2 segregated into 23 resistant to 77 susceptible plants. In the third Burt × White Russian cross the F_1 was resistant and the F_2 segregated into 185 resistant to 45 susceptible plants.

The F_2 of Iowa 105 × Green Russian and Ruakura × White Russian segregated into 300 resistant plants to one susceptible.

(Cooperative investigations between the Iowa Agricultural Experiment Station and the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.)

Varietal tests of peanut (Arachis hypogaea) for wilt resistance. CARL HARTLEY.

Tests were conducted, in Java, of the resistance of various peanut populations to bacterial wilt (*Bacterium solanacearum*). African, South American, and North American varieties, particularly Valencia, proved more susceptible at Buitenzorg than the best Javanese varieties. The local types, in order of decreasing resistance, are Tjina, Holle, and Brol. Within the important Holle type great differences in resistance were found between different populations. The disease is very irregularly distributed in the fields, and numerous replications were necessary to establish the significance of some of the differences observed. Thirty-foot rows were used, so arranged that each variety occurred adjacent to each other variety in one replication of a series, and one only. Practically all plants on sick soil become infected, and the percentage surviving proved the only practicable criterion of relative resistance. This is an index rather than a true measure, resistance being incommensurable. The usual probability methods could not be directly applied to the results, and the significance of differences between two varieties was judged by the proportion of the replications in which one variety surpassed the other. Decided improvements in resistance were quickly obtained in some populations by mass selection. The work is being continued by Dr. Marie B. Schwarz, at the Instituut voor Plantenziekten, employing line-selection methods.

Two new bacterial diseases. MEL T. COOK.

A wilt disease of the egg-plant becomes evident with the formation of the fruit, causing a wilting and dying. When the young plants are inoculated they do not show symptoms of the disease until the fruits are forming. Bacteria are found in great abundance in the vascular tissue. The organism will not attack tomato, pepper or tobacco.

A bacterial disease of cultivated Cosmos becomes evident at almost any period during the life of the plants, causing them to wilt and die. The vascular tissue contains an abundance of bacteria which will reproduce the disease when inoculated into healthy plants. A Fusarium is usually associated with the bacteria but it will not cause the disease. The organism is different from the organism attacking the egg-plant.

The control of white pine blister rust in the Northeastern states. E. C. FILLER.

A resume of this subject up to the time of the Cincinnati meeting was printed in Phytopathology 14: 53, 1924. The speaker was unavoidably absent. The present paper brings the subject up to date.

Presence of the European brown-rot fungus in America. WALTER N. EZEKIEL.

Isolations from fruits from California, and the spur-blight Monilia from Oregon, were identified as the true European brown-rot fungus, *Sclerotinia cinerea* (Bon.) Schroeter. This can be distinguished morphologically by numerous mycelial characters in drop cultures, as well as culturally, from *S. americana* Norton and Ezekiel, which is the species occurring predominantly in this country.

Monilia oregonensis Barss and Posey is probably synonymous with *S. cinerea*, agreeing with it morphologically, culturally, and in its life history.

S. cinerea is expected to be of slight economic importance in this country as compared to *S. americana*.

The importance of removal of mummies and affected fruit in apple bitter-rot control. R. H. HURT.

Observations on the spread of bitter-rot in Virginia apple orchards in 1923 indicated the removal of mummies and affected fruits as valuable procedures in control. These practises were followed in 1924 in an orchard of the Yellow Newtown variety. In one block of 5 trees all mummies were removed during the dormant season. In a second block of 15 trees, affected fruits and all mummies observed were removed at weekly intervals during July and August. Three trees served as controls. All of the trees received a single application of Bordeaux mixture July 17. The results are recorded as follows:

	Mummies removed	Mummies and affected fruits removed	Controls
Number of apples	4911	20,925	4203
Number bitter-rot	236	180	2089
Percentage bitter-rot	4.81	0.86	49.7

The time expended in removal of mummies and affected fruits in the 15-tree block averaged about eleven minutes per tree for the season. On this basis the time expended per acre per season would be approximately eight hours.

Rainfall in relation to ascospore discharge and infection in Venturia inaequalis. F. J. SCHNEIDERHAN.

Ascospore discharge studies of the apple scab fungus have been made at Winchester, Virginia, during three consecutive years. The rainfall of the critical months during the three years has been extremely varied and the variations are strikingly correlated with intensity and duration of ascospore discharge and with intensity of infection. Discharges occurred only during rainfall and the majority of rains within the period of discharge were accompanied by spore discharges. The number and distribution of the discharges during the critical months of the three years together with the length of the discharge periods are recorded as follows:

Year	April	May	June	July	Total	Discharge period (days)
1922	4	9	3	0	16	56
1923	1	4	5	3	13	94
1924	3	7	4	0	14	61

Percentages of apple fruits affected with scab on unsprayed trees within the same small block during the three years are as follows:

Year	Stayman	Winesap	Rome
1922	76.0	97.3	98.4
1923	1.3	7.6	4.2
1924	67.5	77.5	.....

May rainfall apparently determines to a high degree the intensity of infection for the season. The rainfall of this month was 3.63, 1.12, and 10.75 inches for 1922, 1923, and 1924 respectively.

The seasonal development of apple scab. F. J. SCHNEIDERHAN.

Studies of the incidence of scab on apple fruits during 1924 show three infection cycles during the early season, cessation of spread in midsummer, and renewed activity in the fall. Ascospore inoculum applied May 12 to fruit buds of Early Harvest in the late pink stage produced fruit lesions on May 28. Secondary lesions from conidia, carried by drip and wash of rain, appeared June 17 to 19. This cycle represented a gradual curve with the peak on the dates indicated. The third series of lesions represented a sharper curve with the peak on July 1. Studies on Winesap and Stayman showed no further spread of infection during a drought from early July until late August, when infection was resumed following rainfall, and a continuous slow spread, with no clearly defined cycles, occurred until harvest, October 17. A progressive decrease in the rate of enlargement of scab lesions occurred throughout the season. The initial lesions attained an average diameter of 9 mm. within a month, while those which appeared towards harvest were of the "pin head" type and the rate of enlargement was scarcely measurable. Slight, but measurable, enlargement occurred on ripe apples under bell jars in the laboratory.

Frequencies of ascospores of Venturia inaequalis in orchard air. G. W. KEITT and L. K. JONES.

Earlier studies by Frey and Keitt have been continued and extended. Orchard air was drawn by means of a motor-driven suction apparatus through a suitably arranged filter of nitrocellulose and thence through a gas meter which recorded the volume. At the end of the run the nitrocellulose filter was dissolved in a suitable straight-walled, flat-bottomed glass container, in a mixture of alcohol and ether, and allowed to evaporate to a thin, tough, pliable, transparent film. The number of ascospores caught was computed from microscopic counts. This is an adaptation of a technique used by Pasteur. It appears promising for wider applications.

At Sturgeon Bay the apparatus was run in an apple orchard throughout the period of ascospore discharge. The filter was eighteen inches above ground, protected from rain by a shelter which permitted free passage of air. Ascospores were caught at intervals from May 6 to June 29 (apples bloomed June 2–18). The maximal occurrence of ascospores was recorded May 13, when during a rain they were caught through a four-hour period at the average rate of 289 per cubic foot of air. The major portion of the season's discharge occurred before the blooming period.

Further studies of the seasonal development and control of apple scab and cherry leaf spot. G. W. KEITT and L. K. JONES.

The developments of the past season have emphasized the contrasts previously reported by the writers in the seasonal development and control of apple scab and cherry leaf spot. At Sturgeon Bay ascospores of *Venturia inaequalis* were being discharged when the cluster buds of the apple began to open. Infection began in very early stages of unfolding of cluster buds, about 20 days before the "pink" spray was applied. On Dudley plots, where perithecia of the fungus were very abundant, 85 per cent of the blossoms developed sepal infection. Fifty-eight per cent of the blossoms showed sepal infection before the "pink" spray was applied. These results emphasize the importance of sanitation where feasible, and of a "prepink" fungicidal treatment. Under extreme conditions one "prepink" treatment may be insufficient.

Although ascospore discharge of the cherry leaf spot fungus began by May 14 and discharges occurred frequently thereafter, no disease was observed until June 25.

Studies showed that this infection was occasioned by ascospores discharged June 15. Although numerous moist periods occurred in early spring, infection by the cherry fungus was delayed until higher temperatures prevailed, little injury occurring even on unsprayed trees before harvest. Later, however, unsprayed trees were severely infected.

Longevity of the uredospores, teliospores and sporidia of Cronartium ribicola. PERLEY SPAULDING and ANNIE RATHBUN-GRAVATT.

The latter parts of the summers of 1923 and 1924 have been spent in a study of the longevity and viability of the teliospores and sporidia of *Cronartium ribicola* produced naturally upon *Ribes americanum, R. cynosbati, R. glandulosum, R. nigrum, R. odoratum, R. rotundifolium, R. triste* and *R. vulgare*. Incidentally data upon the longevity of the uredospores were secured. Freshly matured teliospores seem to possess equal powers of germination irrespective of the host species upon which they were produced. Their longevity was found to vary from 19 days for one collection of *R. rotundifolium* to 87 days for *R. nigrum*, which was still germinating strongly at the end of the experiment. The "floating" method of germination was found by test to be best. The germination period for teliospores increases directly with their age.

The sporidia need free water to germinate, but the thinnest film is sufficient. When exposed dry upon glass slides, in air with a rather high moisture content, they survived and gave fair germination at all periods of time ranging from 30 minutes up to 26 hours, which was the longest time that a test was run. They survived alternate drying and wetting four and five times quite well and even up to eleven times in scanty numbers. Icing of the teliospores does not appear to have a decided stimulating effect; icing of the sporidia does appear to have a decided stimulative effect in some cases.

Studies on the tip burn disease of lettuce. A. G. NEWHALL.

An investigation has been made of the relation of certain fertilizers, temperature, sunshine, and soil moisture to this disease under field and greenhouse conditions, using Big Boston head lettuce. Osmotic pressure and catalase activity have also been studied. It is concluded that the disease is not of bacterial origin, though bacteria may play an important secondary role. Fluctuations in temperature and moisture supply, particularly in the presence of readily available potassium and nitrogen, induce tip burn. Conversly, slowing down the rate of growth by leaving potash out of the fertilizers and by root pruning or deep cultivation at the proper time have reduced the amount of the disease. Slow growing varieties of head lettuce were found to be less subject to tip burn.

Rye resistant to leaf rust, stem rust, and powdery mildew. E. B. MAINS.

In 1921 two plants of Abruzzes rye highly resistant to leaf rust, *Puccinia dispersa*, were found also to be practically immune from powdery mildew, *Erysiphe graminis secalis*. The next year 7 plants from selfed seed and 277 from open-pollinated seed were studied for susceptibility to leaf rust and mildew and the most promising of these for susceptibility to stem rust, *Puccinia graminis secalis*. The cultures of leaf rust and stem rust were developed from single spores. All types of susceptibility from high resistance to high susceptibility to each of these diseases were found among these plants. Selfs and crosses in this material were studied the next year. From these studies it appears that resistance to each disease is dominant. Plants were found showing resistance to one or more of the diseases and susceptibility to the others, indicating that resistance to each is due to separate factors independently inherited. Many, however,

were resistant to all three diseases. The low self fertility of rye and the dominance of resistance have prevented thus far the certain isolation of a pure strain resistant to all three diseases.

(Cooperative investigations by the Purdue University Agricultural Experiment Station and the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.)

Soil-inhabiting fungi parasitic upon the pea plant and their relation to disease. FRED REUEL JONES.

The soil-inhabiting fungi parasitic upon the pea plant which have been studied in cooperation with the University of Wisconsin may be conveniently divided into three groups based upon the portion of the plant into which the fungus makes its most significant invasion. The first group consists of those species which attack chiefly the growing ends of shoots and roots. The important members are *Corticium vagum* and two species of Pythium. Although thoroughly distributed, they cause important injury only occasionally under favoring conditions.

The second group includes those species entering chiefly the base of the stem near the attachment of the cotyledons of the seed. This is a numerous group consisting largely of species of Fusarium. No species in this group has been found sufficiently cumulative under usual field conditions to cause independently important crop reduction, even with intensive pea culture.

The third group consists of two species entering and traversing extensively the primary cortex of roots. They are a mycorrhizal fungus and *Aphanomyces euteiches* Drechsler. The former appears to be of no economic consequence in peas; the latter is the most widespread cause of destructive root-rot.

Infection of barley by Ustilago nuda through seed inoculation. W. H. TISDALE and V. F. TAPKE.

Floral infection of barley by *Ustilago nuda* has for many years been accepted as proved.

Investigations by the Office of Cereal Investigations, U. S. Department of Agriculture, have shown that dehulled seed of Han River, Tennessee Winter, Wisconsin Winter, Greece, Alaska and Texas Winter barleys, inoculated with spores of *U. nuda*, produce plants with high percentages of loose smut. Nakano Wase remained smut-free, even though the seed was dehulled and smutted. Seedlings from dehulled, inoculated seed of all varieties studied were severely injured and many failed to emerge. Seedlings from dehulled inoculated seed, sown ¾ of an inch deep, emerged in higher percentages than those from similar seed sown 1½ inches deep. Seedlings from inoculated seeds with the hulls not removed were not noticeably injured but some of them were infected. Spores of *U. nuda*, devitalized by pasteurization, were not harmful to seedlings grown from the inoculated seed. Neither viable nor devitalized spores of *U. nuda* were harmful to seedlings of Red Wave wheat grown from inoculated seed.

A microscopic study revealed infection of the coleoptile and first leaves of the plumule of seedlings of both the susceptible varieties and the resistant variety Nakano Wase by *U. nuda*.

Influence of balanced nutrient supply on susceptibility of corn plants to Gibberella saubinetii (Mont.) Sacc. G. N. HOFFER and J. F. TROST.

The relative extents of injury to three strains of corn by infection with *Gibberella saubinetii* (Mont.) Sacc. were varied by supplying young plants of each strain with con-

trolled supplies of mineral nutrients added to washed sand. The basic sand culture contained the proportions of nutrients in the Hartwell and Pember solution. Three other sets carried the basic nutrient proportions excepting that the phosphorus and potassium contents, respectively, were reduced to one-tenth of the basic culture.

Seeds of Burr-Leaming, single-crossed Leaming, and single-crossed Burr-White were supplied by D. F. Jones. Triplicate sets of six uninoculated seeds of each strain and six seeds inoculated with a spore suspension were planted. The plants were grown for five weeks at 20° C. and at uniform moisture in temperature tanks.

The percentage reductions in dry matter per plant for each nutrient treatment are as follows:

Treatment	Strain			Average for three strains
	Burr-Leaming	F_1-Leaming	F_1-Burr-White	
Basic solution	16.5	—2.0	17.1	10.5
Deficient phosphorus	55.6	43.8	14.0	37.8
Deficient potash	26.3	51.3	22.8	33.5

When plants grown under conditions where either phosphate or potash was deficient, injuries induced by *Gibberella saubinetii* were markedly different for each respective strain.

(Cooperative investigations by the Purdue University Agricultural Experiment Station and the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.)

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